U.S. FISH AND WILDLIFE SERVICE

Region 2

Environmental Contaminants Program

RECOMMENDED WATER QUALITY FOR FEDERALLY LISTED SPECIES IN TEXAS

USFWS Technical Report

by

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October 2006

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Cover photo: Texas wild-rice, courtesy of Paula Power

ACKNOWLEDGEMENTS

The authors thank the following reviewers for contributing to this report:

Tom Stehn, Joel Lusk, Bill Seawell, Nathan Allan, Omar Bocanegra, Clare Lee, Allison Arnold, Dawn Whitehead, Carrie Thompson, Paige Najvar, Joe Skorupa, George Noguchi, Tom Brandt, Randy Gibson, Joe Fries, Lynn Wellman, and Jim Dwyer of USFWS; Donna Shaver of U.S. National Park Service; Ray Mathews of Texas Water Development Board; Gary Garrett, Gordon Linam, Tim Jurgenson, Patricia Radloff, Jackie Poole, and Robert Howells of Texas Parks and Wildlife Department; Phillip Jennings, Diane Evans, Ken Williams, Kilty Baskin, Kay Schwab, and Mike Schaub of Region 6 EPA; Bruce Moring and Kent Becher of U.S. Geological Survey; Martha Turner, Lisa O'Donnell, Laurie Dries, David Johns, and Ed Peacock of the City of Austin; and Ken Kramer and Tyson Broad of the Sierra Club.

SECTION 1

INTRODUCTION

This technical report is an assessment of water quality requirements for aquatic species and aquatic-dependent species (e.g., shore birds) that have been listed (or proposed for listing) in Texas as threatened or endangered under the Endangered Species Act of 1973. The document's purpose is to provide preliminary information on water quality for federally listed species and designated critical habitat that can be used by personnel of the U.S. Fish and Wildlife Service (Service) and other agencies in regard to the development of protective water quality criteria and standards. The report may serve as an informational resource by regulatory agencies, permittees, and applicants for actions required under the Endangered Species Act such as development of biological opinions or habitat conservation plans. The report is also intended to serve as technical assistance to Region 6 of the U.S. Environmental Protection Agency (EPA) in conjunction with the "Memorandum of Agreement between the Environmental Protection Agency, Fish and Wildlife Service and National Marine Fisheries Service Regarding Enhanced Coordination under the Clean Water Act and Endangered Species Act" (Federal Register 11202-11217, February 22, 2001). Objectives for the technical report are to

1. Evaluate water quality conditions and known effects that currently exist for aquatic and aquatic-dependent listed species and critical habitat in Texas, and

2. Recommend measures that can benefit conservation of these species and their associated habitat.

The report should be revised whenever new aquatic or aquatic-dependent species are listed in Texas, critical habitat for these species is designated, or new information concerning contaminant toxicity to listed species or their surrogates is discovered or produced through national consultations under the Memorandum of Agreement. Updated versions of the document may be used as initial information in future triennial reviews of the surface water quality standards for the State of Texas as required under the Clean Water Act. Water quality recommendations in the technical report do not constitute rules, regulations, requirements, or project evaluation criteria of the Service. The document also does not create or establish any legal obligations, binding effects, minimum standards, or mandatory criteria to be adopted by the private sector or by government agencies at the Federal, State, or local level.

SECTION 2

SUMMARY

This technical report contains water quality recommendations for animal and plant species in Texas that have been listed as either endangered or threatened under the Endangered Species Act of 1973, as amended. The report discusses aspects of the Clean Water Act and related regulatory authorities that pertain to listed species and critical habitat in Texas. Individual water quality parameters affecting aquatic and aquatic-dependent listed species are assessed in accordance with the Texas Surface Water Quality Standards (TSWQS) which regulates water quality for Texas waters. To differentiate habitat for these species, waters in Texas serving as species habitat are grouped into four broadly defined water categories:

- Category 1 – Aquifer groundwater
- Category 2 – Aquifer groundwater and surface waters in spring runs or spring pools
- Category 3 – Surface waters in spring runs, spring pools, or spring-dependent wetlands
- Category 4 – Surface waters other than surface waters in spring runs, spring pools, or spring-dependent wetlands

The four categories are used to make recommendations for conserving listed species in regard to actions required under the Clean Water Act such as permits for discharge of wastewater or stormwater. Specific major recommendations made in the report for water quality that will help protect listed species in Texas include:

1. Water quality criteria revised as a result of national consultations between EPA and the U.S. Fish and Wildlife Service should be adopted in the TSWQS after promulgation by EPA under section 304(a) of the Clean Water Act.

2. The Comal River, San Marcos River, and Barton Creek in central Texas should have nutrient criteria in the TSWQS to prevent excessive plant growth (including algae) and to limit the potential for invasive species.

3. Permits for discharge of wastewater or stormwater into the Comal and San Marcos rivers should not allow change in pH beyond natural pH ranges associated with these two river systems. To help reduce the potential for adverse pH effects on Texas wild-rice, the current TSWQS criterion for pH in the Upper San Marcos River segment should be revised to a range of 7.1 to 8.4. The pH criterion for the Comal River should also be revised to a range of 6.9 to 7.8 to protect aquatic listed species associated with this river system. For aquatic listed species in Category 4 waters, the pH should not vary by more than two-tenths of a pH unit above or below natural background for discharges in waters with local populations of these species. Effluent should not be discharged in these waters if the effluent is outside of this pH range. To protect aquatic-dependent listed species in Category 4 waters, narrative language should be added to the TSWQS that prevents pH levels in effluent discharges from fluctuating by more than 1.0 pH unit.

4. The current TSWQS temperature criteria for the Upper San Marcos River segment and Comal River should be revised to 75 ^oF (24 ^oC) to help reduce the potential for adverse effects of water temperature on fountain darter reproduction.

5. A turbidity criterion for the San Marcos River should be included in the TSWQS to protect Texas wild-rice and fountain darter.

6. Pending the outcome of national CWA 304(a) consultations between EPA and the Service, the 3.0 mg/L average daily ammonia limit used for listed species habitat in the implementing document of the TSWQS should be revised on an interim basis according to criteria and processes defined in EPA's "Update Of Ambient Water Quality Criteria For Ammonia" and following updates. Ammonia limits at the edge of mixing zones in the Comal River, San Marcos River, and Category 4 waters should be based on daily maximums rather than daily averages, and discharge permits for wastewater and stormwater in these systems should require a testing frequency of three ammonia samples per week.

7. A chronic criterion of 4 μg/g for whole body fish tissue (dry weight) and other restrictive criteria for selenium should be applied in waters with listed species.

8. The Service should be consulted for mixing zones in the Comal and San Marcos rivers, and all other Category 3 waters apart from these two river systems should not have wastewater discharges. Mixing zones should be prohibited for discharges within Category 4 waters in areas with documented occurrences of any listed species if those discharges would likely have an adverse effect on individuals of the species or its associated habitat.

9. Wastewater discharge permits should not allow zones of initial dilution (ZIDs) in any waters where aquatic listed species occur.

10. Design flows used for waters with aquatic and aquatic-dependent species should prevent or minimize critical low-flow conditions below which criteria in the TSWQS are no longer applicable. Discharge permits for waters with aquatic or aquatic-dependent listed species should be based on relatively long critical design flows to account for climatic variability. Permits for discharge into Category 3 waters of the Comal and San Marcos rivers should be based on critical low flows that account for the lowest historical flows on record. Category 4 waters with local populations of listed aquatic species should have permits based on critical low flows of 1Q10 for acute criteria and 7Q10 for chronic criteria

11. For aquatic listed species, the Service recommends that biomonitoring and permit limits should be based on the results of testing with a suite of sensitive surrogate test species representative of listed species and their habitat (fish, aquatic arthropod, etc.). Testing with an aquatic monocot plant species should be developed and used as a surrogate test species for Texas wild-rice. The minimum testing frequency in permits for the Comal and San Marcos rivers should be six WET tests (acute and chronic) per year with both daphnia and fathead minnow used as surrogate test species. As a condition of permits for these two river systems, the Service recommends that WET test results be shared with the Service as soon as possible after testing. The Service also recommends that the "Additional Permit Limits" section of the guidance document for implementing TSWQS criteria be modified to require both acute and chronic testing for discharges subject to WET testing. Whole effluent acute toxicity should be determined to be present if the effluent causes more than 25 percent mortality of test organisms when tested at an effluent concentration of 100 percent. For discharges that result in an in-stream waste concentration of 10 percent or more, limits for whole effluent chronic toxicity should be based on

an in-stream concentration of 100 percent. For discharges resulting in an in-stream waste concentration of less than 10 percent, limits for chronic toxicity in whole effluent testing should be based on the in-stream waste concentration.

12. A designated use of an "Ecologically sensitive water" should be developed for the TSWQS to resolve potential conflicts between current TSWQS criteria and criteria necessary for protection of aquatic or aquatic-dependent listed species. A designated use for aquatic life protection should also be provided in the TSWQS for segments recharging the Edwards aquifer in addition to the current designated use for protection of domestic water supply.

13. The Comal River and Upper San Marcos River segment in the TSWQS should be reclassified into new segments to provide designated uses and criteria that are protective of aquatic listed species. The Upper San Marcos River segment should be reclassified into two segments with the upper segment occurring from the uppermost reaches of Spring Lake down to the river's confluence of Willow Spring Creek. The lower segment of the San Marcos River should run from Willow Spring Creek's confluence down to 1.0 km (0.6 miles) above the river's confluence with the Blanco River. The Comal River should be reclassified into four segments with appropriate uses and criteria: (1) Landa Lake, (2) the new channel of the Comal River, (3) the old channel of the Comal River, and (4) Comal River proper that would run from the confluence of the old and new channels down to the river's confluence with the Guadalupe River.

SECTION 3

REGULATORY INFORMATION

3.1 Endangered Species Act of 1973

The Endangered Species Act of 1973 (ESA), as amended (16 U.S.C 153 *et seq*.), serves to protect plant and animal species that have been listed by the Federal government as either threatened or endangered. Except for certain pest species in Class Insecta, an endangered species is any species that is in danger of extinction throughout all or a significant portion of its range. A threatened species is a species that is likely to become endangered within the foreseeable future throughout all or a significant portion of its range. Species that are either candidate species or species proposed for listing do not have ESA protections until the time of actual listing in the Federal Register; however, Federal agencies are required to confer about potential actions that may affect proposed species or destroy or adversely modify proposed critical habitat. Experimental populations of listed species are protected by the ESA (as modified by special rules in 50 CFR (Code of Federal Regulations) § 17.80-17.85) if these populations are (1) essential experimental populations on either public or private lands or (2) nonessential experimental populations on national parks or national wildlife refuges.

The ESA is jointly administered by the Service and by the National Oceanic and Atmospheric Administration's National Marine Fisheries Service (NOAA NMFS) in the U.S. Department of Commerce. NOAA NMFS (also referred to as NOAA Fisheries Service) has jurisdiction over listed marine and anadromous species (plants, invertebrates, fish, and sea mammals such as whales, seals, and sea lions) whereas the Service has responsibility for all other listed species (terrestrial and freshwater) including some marine mammals such as the manatee. Listed sea turtles are the responsibility of NOAA NMFS whenever these species are in the marine environment; however, the Service is responsible for sea turtles when they are on land to nest. In addition to species listed under the ESA, the Service also has trust resource responsibilities for migratory birds, interjurisdictional fish, certain non-listed sea mammals, and management of national wildlife refuges and national fish hatcheries.

Under section 9 of the ESA and regulation pursuant to ESA section 4(d) found in 50 CFR § 17.31, "take" of animal species listed as threatened or endangered is prohibited. Take of federally listed (listed) animal species includes harassing, harming, pursuing, hunting, shooting, wounding, killing, trapping, capturing, collecting, or attempting to engage in any such conduct. As defined under 50 CFR § 17.3, harm to listed animal species can include significant habitat modification or degradation that results in death or injury to listed species by impairing essential behavioral patterns such as breeding, feeding, or sheltering. Examples of take for listed animal species that can be caused through impairment of water quality include lethality, loss of prey species, sedimentation of breeding areas, abnormal behavioral changes, and induced sublethal effects (e.g., endocrine system disruption).

Take of a listed animal species can only be exempted by the Service or NOAA NMFS. The two agencies (Services) may only allow exemptions for incidental take under limited circumstances through (1) provisions as authorized by a biological opinion in an ESA section 7 consultation or (2) a permit obtained under section 10 of the ESA. Incidental take refers to take that is incidental to, and not the purpose of, carrying out of an otherwise lawful activity. Although take does not apply to listed plant species, the ESA does prohibit the following actions on lands under Federal jurisdiction: (1) removal, damage, or destruction of endangered plant species and (2) removal of threatened plant species. In addition, actions that remove, damage, or cause destruction of endangered plant species in non-Federal lands that are in violation of state or local laws are prohibited.

3.1.1 ESA consultations with Federal agencies

Under the ESA, Federal agencies are required to

1. Conserve listed species (ESA section 7(a)(1)),

2. Consult and confer with the Service or NOAA NMFS (ESA section 7),

3. Conduct biological assessments (ESA section 7(c) and 50 CFR § 402.12), and

4. Prohibit "take" of listed animal species or remove or destroy listed plant species (ESA section 9) without authorization under ESA section 7(a)(2).

Section 7(a)(2) of the ESA requires Federal agencies to insure that any action they authorize, fund, or carry out is not likely to jeopardize the continued existence of any federally listed species or result in the destruction or adverse modification of designated critical habitat. Federal agency actions involving water quality that may be subject to section 7 consultation or conference include, but are not limited to, the following: (1) EPA approval of new or revised state water quality standards, (2) EPA issuance of CWA section 402 National Pollutant Discharge Elimination System (NPDES) permits, and (3) Corps of Engineers issuance of CWA section 404 discharge permits for dredged or fill material in waters of the U.S. The Service's guidance for ESA's section 7 is available at http://endangered.fws.gov/section7.

Federal agencies must consult or confer with the Services when there is discretionary Federal involvement or control over the action, whether apparent (e.g., issuance of a Federal permit), or less direct (e.g., Federal oversight of a program operated by a State). Before initiating an action, the Federal action agency (the agency planning a specific action) or its non-Federal permit applicant may ask the Services to provide a list of threatened, endangered, proposed, and candidate species and designated critical habitats that may be present in the project area.[1] If the Services respond that listed species or critical habitat are not present in the project area, consultation is concluded for that particular action since the Federal action agency has no further obligation under section 7(a)(2) of the ESA. When a species or critical habitat is present, the Federal action agency must then determine whether the project may affect the listed species or critical habitat.[2] Consultation is required if a proposed action may affect a listed species or designated critical habitat. Informal consultations between the Federal agency initiating the action and the Services occur when the activity may affect, but is not likely to adversely affect, listed species or their critical habitats. Informal consultations are used to

1. Clarify presence of listed species or designated critical habitat,

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[1] Species currently listed in Texas can be accessed at the Southwest Region website of the Service at http://ifw2es.fws.gov/EndangeredSpecies/.

[2] Determination of effects from a proposed action on listed species or critical habitat depends largely on the nature and duration of the effect itself. The nature of an effect can be related to (1) elements of the species' life cycle; (2) size, variability, or distribution of species populations; or (3) primary constituent elements of critical habitat. The duration of an effect may involve (1) a short-term event whose effects are relaxed almost immediately (pulse effect), (2) a sustained, long-term, or chronic event whose effects are not relaxed (press effect), or (3) a permanent event that sets a new threshold for some feature of a species' environment (threshold effect). Effects on a species or its habitat can be (1) adverse or beneficial and (2) direct or indirect (e.g., loss of prey base).

2. Determine whether any adverse effects to listed species or critical habitat by the proposed action can be avoided or summarily minimized,

3. Explore ways to modify the action to reduce or remove adverse effect to species or critical habitats,

4. Determine whether formal consultation is needed with the Services, or

5. Explore the design or modification of an action to benefit the species.

An informal consultation is concluded when (1) the action agency determines that the project does not adversely affect any listed species (i.e., the effects are completely insignificant, discountable, or beneficial) and (2) the Services concur in writing that the proposed action is not likely to adversely affect any listed species or critical habitat.

Formal consultation is required with the Services if the Federal action agency or the Services determine that a project is likely to adversely affect a listed species or designated critical habitat. The process for formal consultation is initiated by the action agency by submitting a written request to the Services. The action agency can initiate formal consultation on a number of similar actions within the same geographic area (i.e., regional or ecosystem consultations) or a portion of a comprehensive plan of action (i.e., incremental step consultations) as long as the effects of the entire action are considered. To comply with ESA section 7 regulations (50 CFR § 402.14(c)), an initiation package is submitted with the request for formal consultation and must include all of the following:

1. A description of the action to be considered;

2. A description of the specific area that may be affected by the action;

3. A description of any listed species or critical habitat that may be affected by the action;

4. A description of the manner in which the action may affect any listed species or critical habitat, and an analysis of any cumulative effects;

5. Relevant reports, including any environmental impact statements, environmental assessments, biological assessment or other analyses prepared on the proposal; and

6. Any other relevant studies or other information available on the action, the affected listed species, or critical habitat.

The ESA requires most formal consultations to be conducted within 90 days. In addition, regulations for implementing the ESA require the Services to document within 45 days in a biological opinion whether the activity is likely to jeopardize the continued existence of a species or adversely modify its designated critical habitat and what actions, if any, are required to minimize that impact. The 135-d (day) "clock" begins only when the Services have received all necessary information to conduct an independent analysis of effects including, but not limited to, data and other technical information. However, the Services may also request extension of the 135-d time frame until complex or controversial actions are resolved, as appropriate.

Determination as to whether a proposed action undergoing formal consultation would likely jeopardize the species or adversely modify its critical habitat is contained in biological opinions issued by the two Services. The ESA allows the Services to use "the best scientific and commercial data available" as an information standard in their decision-making processes. Normally, a draft biological opinion is transmitted to the action agency (or applicant) for review and is then finalized following receipt of the agency's (or applicant's) comments. The biological opinion may also provide the action agency (or applicant) with a statement that exempts "take" incidental to otherwise lawful activities during project construction or implementation. To minimize the impact of take to listed species, the Services may include non-discretionary reasonable and prudent measures (RPMs) and the "terms and conditions" to implement them in the biological opinion. RPMs and "terms and conditions" can only address actions that (1) occur within the project's action area, (2) involve only minor changes to the project, and (3) reduce the level of take associated with the project. If a jeopardy or adverse modification determination is made, the biological opinion will identify any reasonable and prudent alternatives (RPAs) that would remove the jeopardizing effects. Formal consultation is concluded when the biological opinion is transmitted to the action agency (or applicant).

3.1.2 ESA permit actions involving the private sector and state or local governments

Section 10 of the ESA authorizes the Services to issue permits that can allow actions involving federally listed species that are normally prohibited (e.g., collection of listed species for scientific purposes). The section also gives the Services the authority to provide incidental take permits of listed animal species by non-Federal activities. Unless incidental take of listed animal species has previously been authorized by consultation with the Services under section 7 of the ESA, applicants who believe that their otherwise-lawful actions may cause take of a listed animal species should obtain an incidental take permit under section 10(a)(1)(B). Since the ESA does not prohibit killing or damaging listed plant species on non-Federal lands (except in the event that killing or damaging of those plants is in violation of state or local law), incidental take permits are not issued by the Services for listed plant species. However, the Services cannot issue a permit for incidental take of listed animal species if a proposed action will jeopardize listed plant species in the project area. Incidental take permits may be issued by the Services to private individuals, associations, businesses, and to state, municipal, or tribal governments. A Habitat Conservation Plan (HCP) must accompany any application for an incidental take permit. The purpose of the HCP is to provide measures that will minimize and mitigate impacts to listed species.

3.1.3 Critical habitat

Under the ESA, the Services are required to designate critical habitat for listed species to identify those areas essential to the conservation of listed species and possibly requiring special management considerations. Federal agencies are required to consult with the Services under ESA's section 7 to insure that anything they authorize, fund, or carry out is not likely to destroy or adversely modify critical habitat. In addition, Federal agencies should consult when a proposed action "may adversely modify" critical habitat. Designation of critical habitat affects only ESA section 7 consultations with Federal agencies and does not require any prohibition or place any responsibility for conservation or consultation on non-Federal entities or wholly non-Federal activities that may impact critical habitat. Critical habitat designation therefore does not affect land ownership or establish a refuge, wilderness, reserve, preserve, or other conservation areas. Specific areas designated as critical habitat are found in 50 CFR § 17.95-17.96 and can be accessed on the Service's website at http://criticalhabitat.fws.gov.

By definition, critical habitat involves only areas that are essential to conservation of listed species and generally does not include developed areas, e.g., dikes, levees, diversion structures, water diversion canals outside of natural stream channels, cultivated agricultural land, and developments in residential, commercial, or industrial areas. In determination of critical habitat, the Services must consider physical and biological features such as

1. Space for individual and population growth and for normal behavior;
2. Food, water, or other nutritional or physiological requirements;
3. Cover or shelter;
4. Sites for breeding, reproduction, or rearing of offspring; and
5. Habitats that are protected from disturbance or are representative of the historical geographical and ecological distributions of a species.

Primary constituent elements (as defined in 50 CFR 424.12(b)) must be listed by the Services when designating critical habitat. The primary constituent elements of critical habitat may include but are not limited to

1. Roosting sites,
2. Nesting grounds,
3. Spawning sites,
4. Feeding sites,
5. Seasonal wetland or dryland,
6. Water quantity or quality,
7. Host species or pollinator,
8. Geologic formation,
9. Vegetation type,
10. Tides, and
11. Specific soil types.

In evaluating project effects on critical habitat, the Services must determine that primary constituent elements of critical habitat will not be altered or destroyed by proposed activities. Federal agencies initiating an action that involves a particular critical habitat should evaluate effects of the action on primary constituent elements as part of their biological assessment. Primary constituent elements of critical habitat for aquatic and aquatic-dependent species listed in Texas are summarized in Table 1 below.

3.2 State-Listed Species in Texas

According to State regulations, all vertebrate animal species in Texas that have been listed as endangered under the ESA are required to be listed as endangered by the Texas Parks and Wildlife Department (TPWD). In conjunction with public hearings, a vertebrate animal species may be listed as a threatened species at the discretion of TPWD irrespective of the species' status under the ESA. Only certain classes of invertebrate species (crustaceans and mollusks) may be designated as endangered by TPWD; however, other invertebrates such as insect species may be regulated as non-game species. All plant species designated as either threatened or endangered by the Service under the ESA are concurrently listed by the State. TPWD may also list plant species that have not been listed under the ESA.

Apart from species concurrently listed under the ESA, species listed by the State of Texas do not have habitat protection and have only limited protections for individuals of the species. An animal species listed by the State of Texas is protected primarily against take, possession, transportation, or sale without a State-issued permit. Plant species listed by Texas are protected against commerce and the collection from public land without a permit issued by TPWD. Laws and regulations pertaining to endangered or threatened animal species as designated by the State of Texas are found in Chapters 67 and 68 of the

Table 1. General locations and primary constituent elements of critical habitat that has been designated or proposed for aquatic and aquatic-dependent listed species in Texas. More specific information on critical habitat for these species can be obtained by referencing the cited Federal Register notice.

Comal Springs dryopid beetle (*Stygoparnus comalensis*)	Proposed critical habitat location(s): Comal Springs in Comal County and Fern Bank Springs in Hays County (see 71 FR 40588). Primary constituent elements proposed for critical habitat of the Comal Springs dryopid beetle are (1) high-quality water with pollutant levels of soaps, detergents, heavy metals, pesticides, fertilizer nutrients, petroleum hydrocarbons, and semi-volatile compounds such as industrial cleaning agents no greater than those documented to currently exist and including: (a) low salinity with total dissolved solids that generally range from 307 to 368 mg/L; (b) low turbidity that generally is less than 5 NTUs; (c) aquifer water temperatures that range from approximately 68 to 75 ^{o}F (20 to 24 ^{o}C); and (d) a hydrologic regime with turbulent flows that provide adequate levels of dissolved oxygen in the general range of 4.0 to 10.0 mg/L for respiration of the Comal Springs dryopid beetle; and (2) food supply for the Comal Springs dryopid beetle that includes, but is not limited to, detritus (decomposed materials), leaf litter, and decaying roots.
Comal Springs riffle beetle (*Heterelmis comalensis*)	Proposed critical habitat location(s): Comal Springs in Comal County and San Marcos Springs in Hays County (see 71 FR 40588). Primary constituent elements proposed for critical habitat of the Comal Springs riffle beetle are (1) high-quality water with pollutant levels of soaps, detergents, heavy metals, pesticides, fertilizer nutrients, petroleum hydrocarbons, and semi-volatile compounds such as industrial cleaning agents no greater than those documented to currently exist and including: (a) low salinity with total dissolved solids that generally range from 307 to 368 mg/L; (b) low turbidity that generally is less than 5 NTUs; (c) aquifer water temperatures that range from approximately 68 to 75 ^{o}F (20 to 24 ^{o}C); and (d) a hydrologic regime with turbulent flows that provide Adequate levels of dissolved oxygen in the general range of 4.0 to 10.0 mg/L for respiration of the Comal Springs riffle beetle; (2) food supply for the Comal Springs riffle beetle that includes, but is not limited to, detritus (decomposed materials), leaf litter, and decaying roots; and (3) bottom substrate in surface water habitat of the Comal Springs riffle beetle that is composed of sediment-free gravel and cobble ranging in size from 0.3 to 5.0 inches (8 to 128 millimeters).
Concho water snake (*Nerodia paucimaculata*)	Critical habitat location(s): Concho and Colorado river systems in Coleman, Concho, McCulloch, Runnels, and Tom Green counties (see 54 FR 27378). Primary constituent elements designated for critical habitat of the Concho water snake are (1) stream and reservoir bank integrity to provide areas for the water snakes to rest, bask, and travel between sites, (2) riffle habitats for feeding and resting areas, (3) rocky substrates of different sizes to provide shelter sites for water snakes of all age groups, (4) minimum stream flow requirements (see item 4 of amendment to 50 CFR § 17.95(c)), and (5) water quality maintenance contributing to an ample prey base.
fountain darter (*Etheostoma fonticola*)	Critical habitat location(s): Spring Lake and its outflow, the San Marcos River, in Hays County; downstream from Spring Lake to approx. 0.5 miles (0.8 km) below the Interstate Highway 35 bridge (see 45 FR 47355). Primary constituent elements have not been designated for critical habitat of the fountain darter; however, activities that could adversely modify critical habitat of the species include (1) destruction or significant reduction of aquatic vegetation in Spring Lake and the San Marcos River, (2) impoundments, (3) excessive withdrawal of water, and (4) pollution.

Houston toad (*Bufo houstonensis*)	Critical habitat locations(s): Designated areas of land and water in Bastrop and Burleson counties (see 43 FR 4022). Primary constituent elements have not been designated for critical habitat of the Houston toad; however, typical habitat for the species includes areas with (1) a soil type that allows for the weak burrowing behavior of the species and (2) both temporary and permanent ponds.
Leon Springs pupfish (*Cyprinodon bovinus*)	Critical habitat location(s): Diamond Y Spring and its outflow stream, Leon Creek, in Pecos County; from the head of Diamond Y Spring downstream in Leon Creek to a point 1mile (1.6 km) northeast of the Texas Highway 18 crossing (see 45 FR 54678-54680). Primary constituent elements have not been designated for critical habitat of the Leon Springs pupfish; however, activities that could impact critical habitat of the species include accidental oil spills and excessive groundwater pumping.
Peck's cave amphipod (*Stygobromus pecki*)	Proposed critical habitat location(s): Comal Springs in Comal County and Hueco Springs in Hays County (see 71 FR 40588). Primary constituent elements proposed for critical habitat of the Peck's cave amphipod are (1) high-quality water with pollutant levels of soaps, detergents, heavy metals, pesticides, fertilizer nutrients, petroleum hydrocarbons, and semi-volatile compounds such as industrial cleaning agents no greater than those documented to currently exist and including: (a) low salinity with total dissolved solids that generally range from 307 to 368 mg/L; (b) low turbidity that generally is less than 5 NTUs; and (c) aquifer water temperatures that range from approximately 68 to 75 ^{o}F (20 to 24 ^{o}C); and (2) Food supply for the Peck's cave amphipod that includes, but is not limited to, detritus (decomposed materials), leaf litter, and decaying roots.
Pecos assiminea (*Assiminea pecos*)	Critical habitat location(s): (1) Diamond Y Spring in Pecos County and approx. 4.2 mile (6.8 km) of its outflow and surrounding wetlands ending at approx. 0.5 mile (0.8 km) downstream of the State Highway 18 bridge crossing, (2) approx. 0.5 mile (0.8 km) of Leon Creek and its surrounding wetlands upstream of the confluence with Diamond-Y Draw in Pecos County, and (3) East Sandia Spring in Reeves County including the springhead itself and the surrounding seeps and wetlands (see 70 FR 46304). Primary constituent elements designated for critical habitat of the Pecos assiminea include (1) permanent, flowing, unpolluted, fresh to moderately saline water; (2) moist or saturated soil at stream or spring run margins with native vegetation growing in or adapted to aquatic or very wet environment, such as salt grass or sedges; and (3) stable water levels with natural diurnal and seasonal variation.
piping plover (*Charadrius melodus*)	Critical habitat location(s): Coastal areas in counties of Aransas, Brazoria, Calhoun, Cameron, Galveston, Kenedy, Kleberg, Matagorda, Nueces, San Patricio, and Willacy (see 66 FR 36038). Artificial habitat types (e.g., dredge spoil sites) may be part of critical habitat if the artificial habitat type has some habitat components (e.g., sparse vegetation) and is used by piping plovers. Primary constituent elements designated for the intertidal flat component of piping plover critical habitat include (1) sand and/or mud flats with no or very sparse emergent vegetation, (2) in some cases, flats covered by blue-green algae, (3) adjacent unvegetated or sparsely vegetated sand, mud, or algal flats above high tide with debris, detritus, or microtopographic relief (less than 50 cm above substrate surface) offering refuge from high wind and cold weather. Primary constituent elements designated for the beach/dune component of piping plover critical habitat include (1) surf-cast algae for feeding of prey in beaches and dunes, (2) sparsely

piping plover cont.,	vegetated backbeach (beach area above mean high tide seaward of the dune line or in cases where no dunes exist, seaward of a delineating feature such as a vegetation line, structure, or road) for roosting and refuge during storms, (3) spits (a small point of land, especially sand, running into water) for feeding and roosting, (4) salterns (bare sand flats in the center of mangrove ecosystems that are found above mean high water and are only irregularly flushed with sea water), and (5) areas washed over by high winds for feeding and roosting.
San Marcos gambusia * (*Gambusia georgei*)	Critical habitat location(s): San Marcos River in Hays County from Highway 12 bridge downstream to approximately 0.5 miles (0.8 km) below Interstate 35 bridge (see 45 FR 47355). Primary constituent elements have not been designated for critical habitat of the San Marcos gambusia. However, the thermally constant habitat of the species is characterized by open areas away from the stream banks with a minimum of aquatic vegetation over a mud bottom. Activities that could threaten the habitat include (1) an increase in vegetation, (2) disrupting the mud bottom, or (3) altering the temperature regime.
San Marcos salamander (*Eurycea nana*)	Critical habitat location(s): Spring Lake and its outflow, the San Marcos River, in Hays County; downstream from Spring Lake to approx. 150 feet (46 m) from the Spring Lake Dam (see 45 FR 47355). Primary constituent elements have not been designated for critical habitat of the San Marcos salamander; however, major threats to critical habitat of the species include (1) lowering of water tables in the area such that Spring Lake could become either (2) dry or intermittent, thus exposing algal mats, or (3) exposure of salamanders to predation by disturbance of algal mats and the lake bottom by skin divers.
Texas wild-rice (*Zizania texana*)	Critical habitat location(s): Spring Lake and its outflow, the San Marcos River, in Hays County; downstream from Spring Lake to confluence of the San Marcos River with the Blanco River (see 45 FR 47355). Primary constituent elements have not been designated for critical habitat of the Texas wild-rice; however, activities that could adversely modify the habitat include (1) altering the flow or water quality of the San Marcos River; (2) physically altering the habitat by dredging, bulldozing, or bottom plowing; or (3) disturbing Texas wild-rice by harrowing, cutting, or intensive collecting.
whooping crane (*Grus americana*)	Critical habitat location(s): Designated areas of land and water around Aransas National Wildlife Refuge including San Antonio Bay, Espiritu Santo Bay, Cedar Bayou, and St. Charles Bay in Aransas, Calhoun, and Refugio counties (see 43 FR 20938). Primary constituent elements have not been designated for critical habitat of the whooping crane; however, winter food requirements of the crane such as crustaceans and mollusks are provided by tidal flats and marshes associated with Aransas National Wildlife Refuge.

* San Marcos gambusia is presumed to be extinct within its habitat of the San Marcos River in central Texas (Edwards 1999).

Texas Parks and Wildlife Code and Sections 65.171 - 65.184 of Title 31 of the Texas Administrative Code (TAC). For plant species that have been designated by the State of Texas as endangered or threatened, laws and regulations are contained in Chapter 88 of the Texas Parks and Wildlife Code and Sections 69.01 - 69.14 of the TAC. Additional information on state-listed species can be found at http://www.tpwd.state.tx.us/nature/endang/.

3.3 Regulatory Authorities for Water Quality in Texas

Water quality for aquatic and aquatic-dependent listed species in Texas is primarily regulated by the Clean Water Act of 1972 (CWA). The CWA protects water quality by requiring individual states to establish water quality standards that define uses, protective criteria, and an antidegradation policy for surface waters in the state. State standards are reviewed during a triennial process by EPA which has overall authority for implementing the CWA. Portions of state standards may also be reviewed by EPA if a state conducts an interim revision (e.g., adoption of a site-specific criterion). In Texas, surface water quality is regulated under the Texas Surface Water Quality Standards (TSWQS) which is administered by the Texas Commission on Environmental Quality (TCEQ) pursuant to 30 TAC Chapter 307 and 2 Texas Water Code (TWC) § 26.023. The TSWQS apply to all surface waters of the state.[3]

Under the CWA, criteria are regulatory limits imposed by state water quality standards on pollutants or conditions of a water body to protect existing or designated uses for that particular water body. Criteria in the TSWQS apply to wetlands since wetlands are defined in the standards as part of the surface waters of Texas.[4] Criteria can be either in a narrative format or numerical (e.g., a 24 h (hour) average concentration of 5.0 mg/L for dissolved oxygen). States and Indian Tribes usually adopt numeric criteria based on EPA's recommendations published under CWA section 304(a).

For toxic materials, criteria are primarily based on the toxicity endpoint of an LC_{50} which is the lethal concentration reached in water for 50 percent of tested surrogate animals. LC_{50} toxicity endpoints are developed for aquatic organisms according to

1. Freshwater acute toxicity (based on average lethality over a 1-h period),

2. Freshwater chronic toxicity (4-d averages),

[3] The TSWQS defines surface water in the state as "Lakes, bays, ponds, impounding reservoirs, springs, rivers, streams, creeks, estuaries, wetlands, marshes, inlets, canals, the Gulf of Mexico inside the territorial limits of the state (from the mean high water mark (MHWM) out 10.36 miles into the Gulf), and all other bodies of surface water, natural or artificial, inland or coastal, fresh or salt, navigable or non-navigable, and including the beds and banks of all water-courses and bodies of surface water, that are wholly or partially inside or bordering the state or subject to the jurisdiction of the state; except that waters in treatment systems which are authorized by state or federal law, regulation, or permit, and which are created for the purpose of waste treatment are not considered to be water in the state."

[4] The TSWQS defines wetlands as areas such as swamps, marshes, bogs, prairie potholes, or similar areas that have a predominance of hydric soils that are inundated or saturated by surface or groundwater at a frequency and duration sufficient that normally supports the growth and regeneration of hydrophytic vegetation. Hydric soils are soils that are saturated, flooded, or ponded long enough during a growing season to develop an anaerobic condition that supports the growth and regeneration of hydrophytic vegetation. Hydrophytic vegetation includes plants that can grow in water or substrates that are at least periodically deficient in oxygen during a growing season as a result of excessive water content. Wetlands do not include (1) irrigated farmland acreage; (2) man-made wetlands of less than one acre; or (3) man-made wetlands constructed on or after August 28, 1989 and which was not constructed with wetland creation as a stated objective.

3. Saltwater acute toxicity (1-h averages), and

4. Saltwater chronic toxicity (4-d averages).

Chronic criteria can also be based on endpoints for growth, reproduction, and survival. EPA's procedures for development of water quality criteria are published in "Guidelines for Deriving National Water Quality Criteria for the Protection of Aquatic Organisms and Their Uses" (EPA 1985). After a decision is made that a national criterion is needed for a particular material, all available information concerning toxicity and bioaccumulation for aquatic organisms is collected and reviewed for acceptability. If sufficient acceptable data for 48 to 96-h toxicity tests on aquatic plants and animals are available, the data are used to derive the acute criterion. Chronic or long-term exposure criteria are derived from the ratio of acute to chronic toxicity concentrations when sufficient data are available. To derive criteria for freshwater organisms, results of acceptable acute tests that have at least one species of freshwater animal in at least eight different families are used including all of the following:

- The family Salmonidae in the class Osteichthyes
- A second family in the class Osteichthyes, preferably a commercially or recreationally important warm-water species such as bluegill (*Lepomis macrochirus*) or channel catfish (*Ictalurus punctatus*)
- A third family in the phylum Chordata (may be in the class Osteichthyes, or an amphibian, etc.)
- A planktonic crustacean such as a cladoceran or copepod
- A benthic crustacean (ostracod, isopod, amphipod, crayfish, etc.)
- An insect (mayfly, dragonfly, damselfly, stonefly, caddisfly, mosquito, midge, etc.)
- A family in a phylum (e.g., Rotifera, Annelida, or Mollusca) other than Arthropoda or Chordata
- A family in any order of insect or any phylum not already represented

A similar process is used by EPA to develop criteria that will protect saltwater organisms. CWA section 304(a) criteria for freshwater or saltwater can be related to other water quality characteristics such as pH, temperature, or hardness when justified.

Site-specific criteria may be developed for individual sites based on toxicity data with appropriate species or water conditions. When multiple sources of potential pollutant sources are discharged in effluent, whole effluent toxicity (WET) testing is used as a measure of the aggregate toxic effect on the receiving water rather than individual criteria. In whole-effluent toxicity testing, surrogate test species (fish, invertebrates, etc.) are exposed to serial dilutions of whole (100 percent) discharge effluent to derive toxicity endpoints (e.g., LC_{50}s). The test results are then compared to acute and chronic limits that have been established for individual permits involving effluent discharge. When effluent toxicity exceeds established permit levels, a Toxicity Identification Evaluation/Toxicity Reduction Evaluation (TIE/TRE) may be performed to identify specific toxins that are causing toxicity within the effluent.

Although the CWA primarily regulates water quality in surface waters and does not directly address water quality in groundwaters, some criteria in the TSWQS for certain surface waters are also applicable to groundwater that is hydrologically connected. The TSWQS specifies aquifer protection as a "designated use" for water bodies contributing water to the recharge zone of the Edward aquifer.[5] The purpose of the use designation is to protect domestic water supply in the Edwards aquifer.[6] The designation for aquifer protection applies only to those portions of surface water segments that involve recharge, transition, or contributing zones of the aquifer. In addition to the TSWQS use designation for protection of the Edwards aquifer, the State of Texas has mandated a goal of nondegradation for all groundwater programs; however, State regulations do not have water quality criteria for pollutants found in groundwater (Texas Groundwater Protection Committee 2003).

Along with protections provided by the CWA, some listed species in Texas may be protected by various local and State authorities for water quality management such as the City of Austin's Save Our Springs (SOS) ordinance and TCEQ's Edwards Aquifer Rules. The SOS ordinance and Edwards Aquifer Rules are designed to protect water quality within defined management areas in central Texas. The SOS ordinance pertains to the City of Austin and its extra-territorial jurisdiction (ETJ) whereas the Edwards Aquifer Rules apply to the recharge and transitional zones in ten counties overlying the Edwards Aquifer.[7] The two regulatory authorities establish measures for protecting water quality in the aquifer from various activities such as construction projects; however, they do not contain water quality criteria for groundwater in the Edwards aquifer. The City of Austin's SOS ordinance establishes both best management practices (BMPs) and limits on impervious ground cover that must be implemented within the city's ETJ. BMPs are also required under the Edwards Aquifer Rules to reduce contaminants entering the aquifer or hydrologically connected surface water in the recharge or transitional zones. Structural BMPs are required under the rules if impervious cover of a project site exceeds 20 percent. Regulations found in 30 TAC § 213.6 include requirements for advanced treatment of wastewater at new facilities and prohibits increased loading from existing facilities in the recharge zone. Requirements for wastewater facilities in the transition and contributing zones are also included in 30 TAC § 213. In addition, construction of sites for waste disposal wells, land disposal of toxic or hazardous wastes, and sewage holding tanks are prohibited in recharge or transitional zones. The rules are administered by TCEQ for relevant portions of Bexar, Caldwell, Comal, Guadalupe, Hays, Kinney, Medina, Travis, Uvalde, and Williamson counties. Under a February 14, 2005, letter of concurrence by the Service with TCEQ, non-Federal landowners and other non-Federal managers following voluntary water quality measures in the Edwards Aquifer program for a project will not incur take for certain aquatic federally listed or candidate species unless the project is located within one mile of spring openings that provide habitat for these species. The Service's concurrence letter addresses four listed species (Barton Springs salamander (*Eurycea sosorum*), fountain darter, San Marcos gambusia, San Marcos salamander) and one candidate species, the Georgetown salamander (*Eurycea naufragia*). Additional information on the Edwards Aquifer Rules is listed at TCEQ's website of http://www.tceq.state.tx.us/. The SOS ordinance of the City of Austin can be found at http://www.ci.austin.tx.us/watershed/ordinances.htm.

The Safe Drinking Water Act (SDWA) authorizes the public water supply supervision (PWSS) program for individual states and Indian tribes. It also establishes programs to protect surface and groundwater

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[5] Water quality criteria (both numeric and narrative) in state water quality standards are designed to protect and support a particular use. Designated uses are those uses specified in water quality standards for each water body or segment whether or not those uses are being attained (i.e., goals).

[6] The Edwards aquifer was designated by EPA in 1975 as the first Sole Source Aquifer. Designation as a Sole Source Aquifer protects an area's groundwater resource by requiring EPA review of any proposed projects within the designated area that receive financial assistance from the Federal government.

[7] A recharge zone is the area overlying an aquifer where water can percolate down into the aquifer through sinkholes, cracks, fissures, caves, and other openings in the land surface. A transitional zone is an area that has geologic features such as faults or fractures that potentially allow contaminants in surface water to be transported into the aquifer.

sources of public drinking water. The SDWA establishes maximum contaminant levels (MCLs) of a contaminant in water which can be delivered to any user of a public water system. The SDWA's PWSS is limited to public water supply systems that have a minimum of 15 service connections or serve at least 25 people per day for 60 days per year. The PWSS program does not apply to private domestic groundwater wells. Listed aquatic species with habitat in the Edwards aquifer may be protected indirectly through human health water quality standards established under the SDWA; however, human-oriented MCLs generated by the SDWA may not adequately address toxicity for listed species in aquifer systems (see Appendix A in this document for MCLs required under the SDWA). Water quality parameters necessary for aquatic life below ground such as dissolved oxygen, pH, and turbidity are also not addressed by the SDWA. The SDWA is administered by TCEQ through its groundwater program in accordance with 2 TWC (Texas Water Code) § 26.401.

State or federally mandated environmental programs such as the Resource Conservation and Recovery Act (RCRA) and the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA or Superfund) are designed to remediate contaminated water resources and can help protect water quality for listed species in Texas. Remediation can be required by these programs for superfund sites, permitted and non-permitted waste disposal facilities, leaking petroleum storage tanks, oil fields, and spill sites of hazardous materials or oil-related contaminants. For Texas groundwaters, it is the State's policy that groundwater quality should be restored when possible; however, it may not be technically feasible or cost-effective to restore groundwater to its original quality (Texas Groundwater Protection Committee 2003).

To attain various environmental goals under the CWA and ESA, regulatory agencies typically use different criteria, metrics, and analyses. The CWA has the particular mandate to "restore and maintain the chemical, physical, and biological integrity of the Nation's waters, and where attainable, to achieve a level of water quality that provides for the protection and propagation of fish, shellfish, and wildlife, and for recreation in and on the water." In contrast, the ESA is focused on conservation of federally listed species and the ecosystems that support them. Since CWA criteria are generally designed to protect 95 percent of all fish and aquatic invertebrate taxa, these criteria will protect most aquatic life uses but not necessarily all aquatic organisms. However, aquatic or aquatic-dependent listed species and certain components of their habitat such as prey species may require different criteria for adequate protection. In particular, ESA processes such as section 7 consultations may address toxicological sensitivities or ecological relationships of individual listed species and their aquatic habitat that do not ordinarily occur under general CWA assessments (e.g., toxicity evaluations).

SECTION 4

WATER CATEGORIES AND WATER QUALITY FOR HABITATS OF FEDERALLY LISTED SPECIES IN TEXAS

4.1 Water Categories

Of 88 Texas species currently listed or proposed for listing (here-in-after included with listed species) under the ESA, only 33 species are either aquatic or aquatic-dependent. These listed species include one mammal and a number of birds, reptiles, amphibians, fish, arthropods, mollusks, and plants. Waters in Texas that serve as habitat for aquatic or aquatic-dependent listed species include coastal bays, estuaries, wetlands, ciénegas (desert wetlands), rivers, streams, lakes, ponds, springs, spring runs, spring pools, and an aquifer. Although most of these waters are perennial, they can be ephemeral or intermittent in nature. A number of surface waters with listed species are fed by various aquifers in central and west Texas; however, only the Edwards aquifer and possibly some related groundwaters in central Texas currently have subterranean listed species. Texas waters involving listed species are identified in the "Hydrologic Database for Federally Listed and Candidate Species in Texas" which is provided by the Service on an annual basis to EPA Region 6, TCEQ, Texas Parks and Wildlife Department, Texas Water Development Board, and U.S. Geological Survey. The database is currently listed in TCEQ's guidance document "Procedures to Implement the Texas Surface Water Quality Standards" (Jan. 2003, RG-194 revised).

For regulatory purposes, Texas waters serving as habitat for aquatic or aquatic-dependent listed species can be grouped into four broadly defined water categories:

- Category 1 – Aquifer groundwater
- Category 2 – Aquifer groundwater and surface waters in spring runs or spring pools
- Category 3 – Surface waters in spring runs, spring pools, or spring-dependent wetlands
- Category 4 – Surface waters other than surface waters in spring runs, spring pools, or spring-dependent wetlands

As indicated in Table 2 below, the four categories can be used to differentiate listed species according to (1) aquatic habitat, (2) threats or issues, and (3) pertinent water quality regulations. Category 1 waters within the Edwards aquifer provide habitat for the Texas blind salamander.[8] The salamander is a subterranean species restricted to cave pools, conduits, fissures, and other subterranean features of the aquifer in Hays County (USFWS 1996). Listed aquatic species in Category 2 waters (Comal Springs dryopid beetle, Peck's cave amphipod, San Marcos salamander, and Barton Springs salamander) have

[8] The Texas blind salamander in Category 1 and two salamander species in Category 2 (Barton Springs salamander and San Marcos salamander) are aquatic plethodontid (lungless) salamanders that retain a gilled, juvenile morphology throughout their life cycle instead of metamorphosing into a terrestrial phase (Chippindale et al. 2000).

Table 2. Water categories and respective aquatic habitat, habitat threats or issues, and water quality regulations for aquatic and aquatic-dependent species listed in Texas.

Category 1 – Aquifer groundwater					
Species [1]	**Classification**	**Status** [2]	**Aquatic habitat**	**Habitat threats or issues** [3]	**Water quality regulations**[4]
Texas blind salamander *(Eurycea (= Typhlomolge) rathbuni)*	amphibian (aquatic)	E	Edwards aquifer underlying City of San Marcos in Hays County	aquifer recharge alterations contaminants habitat dewatering hazmat releases sediments stormwater drainage supersaturation well entrainment	CWA*, EAR
Category 2 – Aquifer groundwater and surface waters in spring runs or spring pools					
Species [1]	**Classification**	**Status** [2]	**Aquatic habitat**	**Habitat threats or issues** [3]	**Water quality regulations**[4]
Barton Springs salamander (*Eurycea sosorum)*	amphibian (aquatic)	E	Edwards aquifer, spring outflow areas of Barton Springs complex (springs of Main, Sunken Garden, Eliza, and Upper Barton),and adjacent stretch of Barton Creek within City of Austin in Travis County	contaminants including – heavy metals (sediment) PAHs (sediment) pesticides dissolved oxygen decline effluent discharge excess nutrients habitat dewatering hazmat releases salinity sediments stormwater drainage/runoff supersaturation	CWA†, EAR, SOS
Comal Springs dryopid beetle (*Stygoparnus comalensis*)	insect (aquatic)	E w/PCH	aquifers and spring outlet areas of (1) Comal Springs arising from Edwards aquifer in Comal County and (2) Fern Bank Springs possibly arising from Trinity aquifer, Edwards aquifer, and/or groundwater lost from Blanco River within Hays County	aquifer recharge alterations contaminants habitat dewatering hazmat releases sediments stormwater drainage supersaturation well entrainment	CWA†, EAR

Peck's cave amphipod (*Stygobromus pecki*)	arthropod (aquatic)	E w/CH	Edwards aquifer, spring outflow areas, and shallow groundwater (Hueco Springs only) associated with Comal Springs and Hueco Springs in Comal County	aquifer recharge alterations contaminants habitat dewatering hazmat releases sediments stormwater drainage supersaturation well entrainment	CWA†, EAR
San Marcos salamander (*Eurycea nana*)	amphibian (aquatic)	T‡ w/CH	Edwards aquifer, spring outflow areas of San Marcos Springs, Spring Lake, and upper portion of San Marcos River in Hays County	contaminants including – PAHs (sediment) excess nutrients habitat dewatering hazmat releases invasive species sediments stormwater drainage/runoff supersaturation	CWA†, EAR

Category 3 – Surface waters in spring runs, spring pools, or spring-dependent wetlands

Species [1]	Classification	Status [2]	Aquatic habitat	Habitat threats or issues [3]	Water quality regulations [4]
Big Bend gambusia (*Gambusia gaigei*)	fish	E	spring runs at Rio Grande Village within Big Bend National Park in Brewster County	habitat dewatering invasive species temperature	CWA
Clear Creek gambusia (*Gambusia heterochir*)	fish	E	head spring areas of Clear Creek in Menard County	habitat dewatering invasive species pH temperature	CWA
Comal Springs riffle beetle (*Heterelmis comalensis*)	insect (aquatic)	E w/PCH	springs and spring outflow areas of (1) Comal Springs at Landa Lake in Comal County and (2) San Marcos Springs at Spring Lake in Hays County	contaminants including – PAHs (sediment) PCBs (sediment) habitat dewatering hazmat releases sediments stormwater drainage/runoff supersaturation	CWA, EAR

Comanche Springs pupfish (*Cyprinodon elegans*)	fish	E	springs and spring run areas of Toyah Creek and San Solomon Spring complex (springs of San Solomon, Giffin, Phantom Lake, and East Sandia) including associated irrigation canals in Jeff Davis and Reeves counties	habitat dewatering invasive species irrigation water pesticides salinity	CWA
Devils River minnow (*Dionda diaboli*)	fish	T	spring run areas in (1) Las Moras Creek, Pinto Creek, and Sycamore Creek in Kinney County, and (2) Devils River, Dolan Creek, Phillips Creek, San Felipe Creek, and Sycamore Creek in Val Verde County	contaminants including – ammonia chlorine effluent discharge habitat dewatering invasive species oil spills/hazmat releases sediments stormwater runoff	CWA
fountain darter (*Etheostoma fonticola*)	fish	E w/CH	Spring Lake and San Marcos River above confluence with Blanco River in Hays County	contaminants including – PAHs (sediment) PCBs (sediment) dam impoundments effluent discharge excess nutrients habitat dewatering hazmat releases invasive species pH sediments stormwater drainage/runoff supersaturation temperature turbidity	CWA, EAR
Leon Springs pupfish (*Cyprinodon bovinus*)	fish	E w/CH	springs and spring runs associated with Diamond Y Draw in Pecos County	habitat dewatering invasive species oil spills/hazmat releases	CWA
Pecos assiminea snail (*Assiminea pecos*)	snail (aquatic)	E w/CH	spring runs associated with (1) Diamond Y Draw in Pecos County and (2) East Sandia Spring in Reeves County	habitat dewatering invasive species oil spills/hazmat releases	CWA

Pecos gambusia (*Gambusia nobilis*)	fish	E	springs and spring runs of (1) Diamond Y Draw in Pecos County and (2) Toyah Creek and San Solomon Spring complex (springs of San Solomon, Giffin, Phantom Lake, and East Sandia) including associated irrigation canals in Jeff Davis and Reeves counties	habitat dewatering invasive species oil spills/hazmat releases salinity temperature	CWA
Pecos (= puzzle) sunflower (*Helianthus paradoxus*)	plant (aquatic-dependent)	T	wetlands and ciénegas associated with (1) Diamond Y Draw and Leon Creek in Pecos County and (2) East Sandia Spring in Reeves County	habitat dewatering oil spills/hazmat releases	CWA
San Marcos gambusia § (*Gambusia georgei*)	fish	E w/CH	Spring Lake and upper portion of San Marcos River in Hays County	contaminants including – PAHs (sediment) dam impoundments excess nutrients habitat dewatering hazmat releases invasive species pH sediments stormwater drainage/runoff supersaturation temperature	CWA, EAR
Texas wild-rice (*Zizania texana*)	plant (aquatic)	E w/CH	San Marcos River above confluence with Blanco River in Hays County	contaminants including – PAHs (sediment) dam impoundments debris/recreation impacts effluent discharge excess nutrients habitat dewatering hazmat releases invasive species pH sediments stormwater drainage/runoff temperature turbidity water flow velocity	CWA, EAR

Category 4 – Surface waters other than surface waters in spring runs, spring pools, or spring-dependent wetlands					
Species [1]	**Classification**	**Status** [2]	**Aquatic habitat**	**Habitat threats or issues** [3]	**Water quality regulations** [4]
American alligator (*Alligator mississipiensis*)	reptile (aquatic)	SAT	inland waters near coastal areas	oil spills/hazmat releases	CWA
Arkansas River shiner (*Notropis girardi*)	fish	T w/CH**	Canadian River above and below Lake Meredith	CAFOs contaminants including – selenium dam impoundments effluent discharge excess nutrients habitat dewatering invasive species oil spills/hazmat releases sediments stormwater runoff	CWA
bald eagle (*Haliaeetus leucocephalus*)	bird (aquatic-dependent)	T	rivers, lakes, and reservoirs	CAFOs contaminants oil spills/hazmat releases	CWA
brown pelican (*Pelecanus occidentalis*)	bird (aquatic-dependent)	E	coastal bays and waterways	contaminants oil spills/hazmat releases	CWA
Concho water snake (*Nerodia paucimaculata*)	reptile (aquatic-dependent)	T w/CH	streams, rivers, ponds, lakes, and reservoirs associated with watersheds of the Concho and Colorado rivers downstream to (and including) Colorado River Bend State Park	CAFOs contaminants effluent discharge habitat dewatering hazmat releases prey thermal sensitivity stormwater runoff	CWA
green sea turtle (*Chelonia mydas*)	reptile (aquatic)	T	coastal bays and waterways	contaminants debris oil spills/hazmat releases red tides	CWA
hawksbill sea turtle (*Eretmochelys imbricate*)	reptile (aquatic)	E w/CH**	coastal bays and waterways	contaminants debris oil spills/hazmat releases red tides	CWA

Houston toad (*Bufo houstonensis*)	amphibian (aquatic-dependent)	E w/CH	ponds, streams, lakes, and ephemeral water bodies	contaminants effluent discharge habitat dewatering oil spills/hazmat releases stormwater runoff	CWA
interior least tern (*Sterna antillarum*)	bird (aquatic-dependent)	E ††	streams, rivers, ponds, lakes and reservoirs	CAFOs contaminants effluent discharge oil spills/hazmat releases	CWA
Kemp's ridley sea turtle (*Lepidochelys kempii*)	reptile (aquatic)	E	coastal bays and waterways	contaminants debris oil spills/hazmat releases red tides	CWA
leatherback sea turtle (*Dermochelys coriacea*)	reptile (aquatic)	E w/CH**	coastal bays and waterways	contaminants debris oil spills/hazmat releases red tides	CWA
Little Aguja pondweed (*Potamogeton clystocarpus*	plant (aquatic)	E	Little Aguja Creek and associated streams in Jeff Davis County	dam impoundments effluent discharge habitat dewatering	CWA
loggerhead sea turtle (*Caretta caretta*)	reptile (aquatic)	T	coastal bays and waterways	contaminants debris oil spills/hazmat releases red tides	CWA
manatee (*Trichechus manatus*)	mammal (aquatic)	E w/CH**	coastal bays and waterways	contaminants debris oil spills/hazmat releases red tides	CWA
piping plover (*Charadrius melodus*)	bird (aquatic-dependent)	T w/CH	coastal shoreline areas and the mud flats on offshore coastal islands	contaminants tidal flat effluents oil spills/hazmat releases	CWA
whooping crane (*Grus americana*)	bird (aquatic-dependent)	E w/CH	coastal wetlands in Aransas, Calhoun, and Refugio counties; Byers Lake in Clay County; and Red River along Texas-Oklahoma border	contaminants habitat dewatering oil spills/hazmat releases salinity	CWA

[1] Species

§	=	San Marcos gambusia is presumed to be extinct (Edwards 1999).

[2] Status

CH	=	Critical Habitat (designated or proposed in Texas unless annotated as **)
E	=	Species that is in danger of extinction throughout all of its range or a significant portion
SAT	=	Similarity of appearance to a threatened taxon. The alligator is designated as SAT due to similarity of appearance with the endangered American crocodile (*Crocodylus acutus*). SAT-designated species do not receive ESA protections and do not require Federal agencies to consult under ESA section 7.
P	=	Proposed (species or critical habitat)
T	=	Species that is likely to become endangered within the foreseeable future throughout all of its range or a significant portion
‡	=	Special rule applies. Under the special rule for the San Marcos salamander, "take" for the species is allowed in accordance with applicable State law (see 45 FR 47355).
**	=	CH designated (or proposed) outside of Texas
††	=	Restricted to populations found in the "interior" of the United States. In Texas, the least tern receives ESA protections throughout the State except for coastal areas that are within 50 miles (80 km) of the Gulf Coast.

[3] Habitat threats/issues

CAFOs	=	Confined animal feedlot operations
hazmat	=	Hazardous materials
PAHs	=	Polycyclic aromatic hydrocarbons
PCBs	=	Polychlorinated biphenyls

[4] Water quality regulations [Note – Environmental regulations for hazardous materials (e.g., Superfund Act) pertain to any release of these materials in water or on land]

CWA	=	Clean Water Act
CWA*	=	Clean Water Act applies only through the aquifer protection use designated in the TSWQS for certain segments in the contributing, recharge, and transition zones of the Edwards aquifer. TSWQS criteria for protection of the aquifer use apply only to surface water in the segments and do not apply to habitat of listed species in aquifer groundwater.
CWA†	=	Clean Water Act applies to (1) surface water in species habitat and (2) aquifer protection use designated in the TSWQS for certain segments in the contributing, recharge, and transition zones of the Edwards aquifer. TSWQS criteria to protect aquifer use apply only to surface water in the segments and do not apply to species habitat in aquifer groundwater.
EAR	=	Edwards Aquifer Rules.
SOS	=	Save Our Springs ordinance of the City of Austin

habitat in both aquifer groundwater and surface waters associated with aquifer spring outlets (Barr and Spangler 1992, Barr 1993, USFWS 1996, USFWS 2005). The Edwards aquifer is the principal source of groundwater for habitat of all four species; however, the aquifer may only serve as a secondary source for some of the springs that serve as habitat for the two arthropod species. Peck's cave amphipod and Comal Springs dryopid beetle are most commonly found at Comal Springs in Comal County, but the two species also occur at other spring sites. The amphipod also occurs at Hueco Springs in Comal County, and the dryopid beetle has been found at Fern Bank Springs in Hays County. Comal Springs itself is fed by the Edwards aquifer; however, the other two springs potentially have different groundwater sources. Hueco Springs is recharged locally from within the watershed basin of the Guadalupe River and possibly by the San Antonio segment of the Edwards aquifer (Guyton and Associates 1979). Although the upper part of the Glen Rose Formation [Trinity aquifer] may serve as the primary groundwater source for Fern Bank Springs, water discharged from the springs could also be due to (1) drainage from the nearby Edwards aquifer recharge zone, (2) water lost from the Blanco River, or (3) a combination of all three sources (G. Veni, George Veni and Associates, 2006 – pers. comm.).

The Comal Springs dryopid beetle and Peck's cave amphipod in Category 2 waters are subterranean arthropods that principally exist in aquifer groundwater but are also found to a very limited extent in spring outflow areas in surface water (Barr and Spangler 1992, Bio-West 2003). However, the eyeless condition of Peck's cave amphipod and vestigial eyes in the Comal Springs dryopid beetle make these two species highly vulnerable to predation in surface waters. Barr (1993) noted that effects on the dryopid beetle and amphipod from extended loss of spring flow and low aquifer levels could not be predicted due to limited knowledge about their life cycles.

In contrast to the two arthropod species in Category 2, the San Marcos and Barton Spring salamanders have relatively extensive habitat areas in surface water in addition to groundwater habitat in the Edwards aquifer. Surface water habitat for the San Marcos salamander within the City of San Marcos occurs in (1) headsprings of the San Marcos River, (2) Spring Lake, and (3) a short distance (< 200 ft, 61 m) in the San Marcos River that lies downstream from the dam impounding Spring Lake. The Barton Springs salamander has surface water habitat in springs, spring runs, and a stream (Barton Creek) that are located in Zilker Park near downtown Austin. The four springs (collectively known as Barton Springs) are

1. Main Springs (also known as Parthenia Springs),
2. Eliza Springs,
3. Sunken Garden Springs (also known as Old Mill Springs), and
4. Upper Barton Springs.

The springs occur within 0.25 miles (0.4 km) of each other and are hydrologically connected belowground to one another to varying degrees. Barton Creek flows directly through two of the four springs (Main Springs and Upper Barton Springs), and the creek itself provides part of the surface water habitat for the salamander within the Barton Springs complex.

The full extent to which species in Category 1 (Texas blind salamander) and Category 2 (Barton Springs salamander, Comal Springs dryopid beetle, Peck's cave amphipod, and San Marcos salamander) inhabit subterranean areas in the Edwards aquifer away from spring outlets is unknown. Surveys for these species within the aquifer are greatly limited by current technology and by the availability of sites for observation. Apart from occasional sighting at San Marcos Springs, the Texas blind salamander has also been observed within a number of subterranean cave pools, fissure pools, and wells (e.g., Ezell's and Rattlesnake cave pools, F. Johnson's and Primer's fissure pools, and Texas State University-San Marcos artesian well) that are distributed across the City of San Marcos in Hays County. The Barton Springs and San Marcos salamanders have only been sighted in surface water and spring orifices; however, these species have morphological features associated with subterranean species and can apparently retreat back into (or be discharged from) the aquifer. Krejca (2005) observed Peck's cave amphipods at the bottom of a well that is located 360 ft (110 m) away from the largest spring outlet at Comal Springs. The Comal Springs dryopid beetle may be limited to aquifer areas close to spring outlets since the species does not swim and larval stages may require access to terrestrial sites (Barr 1993).

Surface waters of Category 3 provide habitat for 12 aquatic species listed in Texas (fish, arthropod, mollusk, and plants). Species and habitats in Category 3 are entirely dependent on perennial base flows from springs that originate from aquifers in central and west Texas.[9] Aquifers in Texas known to contribute or could possibly contribute to surface water habitat of aquatic listed species in Category 3 include the Edwards, Edwards-Trinity, Rustler, Cenozoic Pecos Alluvium, West Texas Bolsons, and Capitan Reef aquifers (USFWS 1996, Anaya 2001, Boghici and van Broekhoven 2001, Jones 2001, Mace 2001, Uliana 2001). Spring flows from the Edwards aquifer at Comal Springs and San Marcos Springs in central Texas support surface water habitat for the Comal Springs riffle beetle, fountain darter, San Marcos gambusia, and Texas wild-rice. The Rustler aquifer is the main source of water for Diamond Y Spring in Pecos County (Boghici 1997, Boghici and van Broekhoven 2001). This spring provides ciénega habitat for the Leon Springs pupfish, Pecos assiminea snail, Pecos gambusia, and Pecos sunflower. Surface water habitat for the Devils River minnow in Val Verde and Kinney counties is provided by springs from the Edwards-Trinity aquifer and related aquifers (Anaya 2001). Water withdrawals from the Edwards-Trinity aquifer could reduce spring flows into the head pool of Clear Creek in Menard County which forms the sole habitat of the Clear Creek gambusia (Edwards 2001, Edwards et al. 2004). Brune (1981) attributed the source of spring flow for habitat of the Big Bend gambusia within Rio Grande Village in Big Bend National Park to a fault in Santa Elena limestone. A number of springs in the San Solomon Springs system (San Solomon, Giffin, Phantom Lake, and East Sandia) near Balmorhea, Texas, in Jeff Davis and Reeves counties provide habitat for the Comanche Springs pupfish, Pecos assiminea snail, Pecos gambusia, and Pecos sunflower. Spring flows for the San Solomon Springs system may involve the Edwards-Trinity, Cenozoic Pecos Alluvium, West Texas Bolsons, and Capitan Reef aquifers (TWDB 2005). A local and a regional groundwater flow system provide flows for the spring system (TWDB 2005). The local flow system is fed from the Davis Mountains to the south of the spring complex whereas the regional groundwater flow system may involve the Apache Mountains to the west of the spring system and the Delaware Mountains area to the northwest (Sharp 2001, Sharp et al. 2003, TWDB 2005).

Flows in spring-run systems of Category 3 can range from peak flows over 400 cfs (11.3 m^3/s) for Comal Springs in Comal County (Fahlquist and Slattery 1997) to flows as low as 0.1 cfs (2.8 dm^3/s) or less in some west Texas springs (N. Allan, USFWS, 2005 – pers. comm.). Apart from the exceptionally large spring-run systems of the Comal River and Upper San Marcos River in central Texas, surface waters in these systems generally do not flow downstream more than several kilometers from the headspring area (Edwards et al. 1989). The Comal River flows for a distance of 3.3 miles (5.3 km) from its origin in Comal Springs within Landa Lake in Comal County down to the river's confluence with the Guadalupe River. The Upper San Marcos River (hereafter referred to as the San Marcos River) is the stretch of the river that runs downstream for a distance of 5.1 miles (8.2 km) from San Marcos Springs within Spring Lake in Hays County down to the river's confluence with the Blanco River.

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[9] Base flow is defined by the U.S. Geological Survey as flow in a channel that is sustained by groundwater discharge in the absence of direct runoff.

Populations of listed species in Category 3 waters ordinarily do not occur downstream in spring-run systems beyond the point where (1) surface water from other sources within the watershed becomes the dominant influence on water quality, or (2) the original spring flow is lost through ground seepage or by evaporation before reaching other surface waters. In the San Marcos and Comal rivers, habitat for spring-dependent listed species occurs downstream throughout these rivers almost to their respective confluences with the Blanco and Guadalupe rivers. Due to their limited habitat ranges, aquatic species in this category can be greatly impacted during drought or by water withdrawals. Bowles et al. (2003) suggested that the Comal Springs riffle beetle may be able to survive drought periods at Comal Springs through (1) aestivation, (2) retreating back into spring outlets, or (3) burrowing down into groundwater of the Comal River. However, the extent to which the species is impacted by loss of water during a drought is unknown (Bowles et al. 2003).

As indicated in Table 2, listed species and habitat in Category 3 waters are particularly susceptible to invasive species. The Comal and San Marcos rivers in central Texas have considerable numbers of invasive species including giant rams-horn snail (*Marisa cornuarietis*), elephant ear (*Colocasia esculenta*), water trumpet (*Cryptocoryne becketti*), hydrilla (*Hydrilla verticillata*), and various fish species (USFWS 1996, Bowles and Bowles 2001). In addition to hybridization and competition with other *Gambusia* species, invasive plants may have contributed to the probable extinction of the San Marcos gambusia. Extensive stands of introduced vegetation such as elephant ear along stream banks in the San Marcos River may have reduced the availability of habitat for the San Marcos gambusia (USFWS 1980).

Both aquatic and aquatic-dependent listed species occur in Category 4 waters. Habitats of listed species in Category 4 waters include intermittent or ephemeral waters (e.g., breeding sites of Houston toad), wetlands (e.g., wintering areas of whooping crane), and large, perennial surface waters such as rivers or coastal bays (e.g., bald eagle and sea turtles). Listed animal species (e.g., sea turtles) associated with Category 4 waters tend to be relatively mobile with respect to their aquatic environments as compared to species in other water categories and in some instances may migrate between waters with different levels of water quality during life cycle events such as reproduction. Category 4 waters are relatively uninfluenced by discharge from aquifers since spring water is changed downstream due to atmospheric interactions, geological influences, human cultural effects, and other various processes (Hem 1992). Some surface water in this category may not enter any aquifer or acquire water quality characteristics of groundwater during the hydrological cycle, e.g., runoff of rainfall into a coastal bay from adjacent lands.

4.2 Water Quality in Aquatic Habitats of Listed Species

High water quality in the Edwards aquifer is necessary for listed species with habitat in the aquifer (water categories 1 and 2). Aquatic species (arthropods and amphibians) in these two categories have very low tolerance for degradation of water quality due to low body mass, high permeability of gill structures and body surfaces, restricted food bases, and other physiological or ecological factors. Although the relatively high level of water quality inside the Edwards aquifer has sustained these species up to the present, pollutants have been found to be increasing in wells and spring outlets of the aquifer (Hauwert and Vickers 1994, City of Austin 1997, Turner 2000, Herrington et al. 2005). These pollutants include sediment and contaminants such as heavy metals, polycyclic aromatic hydrocarbons (PAHs), pesticides, and organic solvents. Pollutants are carried into the Edwards aquifer either by infiltration of water into soils overlying the aquifer or by drainage of water into aquifer recharge features (sinkholes, caves, fissures, fractures, and other surface openings) that are located in uplands or stream bottoms. In addition to stream flow in various streams and rivers in central Texas, surface water within the watershed of the Edwards aquifer can undergo a flow sequence of (1) drainage as runoff water from a contributing watershed into recharge features in the aquifer's recharge zone; (2) transfer as groundwater within the aquifer through fissures, faults, conduits, or other channels that have been enlarged by dissolution processes; and (3) emergence of the groundwater at the land surface as spring outflows. Water-borne pollutants can therefore be introduced into the aquifer through this underground flow sequence. In comparison to other types of aquifers, karstic aquifers such as the Edwards aquifer tend to transmit pollutants rather than degrade them (Ford and Williams 1994).[10] Transient pulses of pollutants in groundwater and spring outflows of karstic aquifers can occur within hours to a few days after major precipitation events (Field 1989). Karstic aquifers are highly susceptible to pollutants due to

1. Relatively little filtration of water by shallow surface soils overlying these types of aquifers;

2. Direct runoff of surface water bearing pollutants into aquifer recharge features such as sinkholes, fissures, and cracks;

3. Absence of granular textures within these aquifers that ordinarily enhance mechanical filtration or biological degradation;

4. Rapid flow velocities within aquifer conduits; and

5. Relatively short periods for degradation of groundwater pollutants by microorganisms and other time-dependent processes (Field 1989, Ford and Williams 1994, Maire and Pomel 1994).

Due to expanding urbanization in central Texas, the Barton Springs salamander (a Category 2 species) and possibly other aquatic listed species associated with the Edwards aquifer can be expected in the future to have greater impacts from contaminants within the aquifer as well as in surface water habitat. Herrington et al. (2005) reported degrading trends at Main Barton Springs for 15 parameters of water quality, including dissolved oxygen and nitrate/nitrite, for the years of 1978-2005. With respect to listed species with habitat in the Edwards aquifer, water quality is generally expected to remain adequate up to a point when contaminant loading from increased urban development in the contributing watersheds of the aquifer reaches levels that can impact aquatic habitat of these listed species (City of Austin 1997, Mahler et al. 1999). A primary reason for the existing high level of water quality in the Edwards aquifer is the relatively large extent of currently undeveloped land found within contributing watersheds of the aquifer. As additional areas are developed, the water quality of the aquifer's groundwater may be threatened by sources of pollution such as septic systems and by increases in impervious cover. Impervious cover (paved roadways, concrete sidewalks, rooftops, etc.) in urbanized areas can restrict adequate decomposition or removal of contaminants during stormwater events, and increases in impervious cover may eventually impact water quality of the Edwards aquifer to a greater degree (City of Austin 1990). Impacts to aquatic systems from increased impervious cover include reduction in the abundance of macrobenthic taxa and altered food webs (Holland et al. 2004). Spills or release of hazardous materials such as crude oil, MTBE (methyltertiarybutyl ether), PCE (perchloroethylene or tetrachloroethylene), TCE (trichloroethylene), and perchlorate into the aquifer could also impact listed species and their habitat.

Except for heavy rainfall events or long-term periods of drought, spring-run systems in Category 3 typically have clear water with relatively little variation in temperature or flow (Hubbs 1995). Due to the consistency in habitat conditions in Category 3, some species (e.g., fountain darter) can reproduce throughout the year. Certain listed species in Category 3 waters may have particular habitat requirements such as flowing water with riffles (e.g., Comal Springs riffle beetle), an undisturbed streambed (e.g., fountain darter), or a gravel-cobble bottom substrate (e.g., Devils River minnow) (Brown 1987, USFWS 1996, Garrett et al. 2004). Other possible requirements for species in Category 3 waters include (1)

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[10] Karst is a term generally applied to landscapes that are formed by dissolution of limestone bedrock and have characteristics of sinkholes, caves, dry valleys (little or no surficial drainage), sinking streams, springs and seeps, solution valleys, and various sculpted landforms at the bedrock surface (Kastning and Kastning 1999).

specific types and extent of vegetative cover and (2) biological integrity of the habitat sufficient to preclude invasive species.

Similar to species in water categories 1 and 2, listed species in Category 3 waters (fish, arthropods, mollusks, and plants) require unimpaired water quality within their habitat and can be impacted by degradation of water quality due to physiological or ecological factors (e.g., high permeability of body surfaces and gill structures to uptake of ions and gases). A number of listed species associated with this water category require spring flows of high quality, non-saline water with constant temperatures, e.g., spring-dependent species of the Edwards aquifer. However, some spring-run habitats in west Texas have relatively high salinities that can limit encroachment by invasive species capable of competing or hybridizing with native listed species (Echelle and Echelle 1980, USFWS 1981). Invasive species are often more tolerant of modified or degraded ecological conditions than native species and can affect aquatic habitats through disturbance of bottom substrates, alteration of nutritional cycling, loss of biological integrity, depression of dissolved oxygen levels, or other effects (R. Howells, TPWD, 2005 – pers. comm.). Listed aquatic species in central and west Texas may be protected against hybridization and competition with invasive species through specific physicochemical regimes of temperature, pH, and salinity that occur within spring runs or spring pools (Hubbs 2001).

The influence of aquifers and groundwater flow systems in west Texas on water quality in Category 3 waters is less well understood than the Edwards aquifer's influence on water quality for similar waters in central Texas. Aquifers that potentially provide habitat to listed aquatic species in west Texas include the Rustler, Capitan Reef, West Texas Bolsons, Cenozoic Pecos Alluvium, and Edwards-Trinity aquifers (Mace 2001). Aquifers in west Texas have had relatively little study in general, and groundwater flow paths to springs that discharge into habitat of listed species have not been adequately established (Mace 2001, TWDB 2005). Anthropogenic activities that may affect groundwater quality in these aquifers include pumpage, agricultural runoff, and oil field operations (Anaya 2001, Jones 2001). Apart from the threat of water loss for aquatic habitat, research is particularly needed to determine the effects on water quality (temperature, salinity, etc.) in habitat of listed aquatic species as a result of withdrawals from water systems in west Texas.

Since aquatic listed species in Category 3 waters have relatively limited habitat ranges, these species are highly vulnerable to habitat modifications such as degradation of water quality. Species in Category 3 that are associated with spring outflows of the Edwards aquifer may be affected by increases in contaminants into the aquifer that are the result of urban development in contributing watersheds. Stormwater drainage in urbanized areas can significantly affect threatened or endangered aquatic species with limited ranges (Walsh et al. 2004). Listed species dependent on spring flows from west Texas aquifers potentially can be impacted by spills from oilfield activities, e.g., aquatic listed species resident to Diamond Y Draw in Pecos County, Texas. In addition to causing loss of aquatic habitat, water withdrawals may possibly impact listed species in this water category through a decrease in water quality and other factors. As an example, reduced current velocities in the San Marcos River from drought, dams, or water withdrawals could affect submergent leaf growth of Texas wild-rice by limiting CO_2 uptake from the river water (Power 2002, Power and Doyle 2004).

In contrast to other water categories, populations of listed species in Category 4 waters are generally distributed over an array of surface waters (bays, rivers, etc.) with differing conditions of water quality. An exception is Little Aguja pondweed which is endemic to intermittent streams in the watershed of Little Aguja Creek in Jeff Davis County. As compared to species with aquifer or spring-influenced habitat, listed species in Category 4 can be relatively tolerant of areas with varying degrees of water quality inside their range. However, resident populations of listed species associated with this water category can still be impacted by release of contaminants or by poor water quality caused by actions such as water withdrawals. Due to population increases in Texas, the trend toward reuse of water could also impact aquatic and aquatic-dependent listed species by affecting conditions of water quality within their habitat such as salinity.

4.3 Recommended Water Quality for Water Categories with Listed Species

EPA and the Services are currently conducting national consultations on EPA's recommended aquatic life criteria as provided under section 304(a) of the CWA. The interagency consultations are being conducted under a Memorandum of Agreement (MOA) (66 FR 11202) that was initiated on January 18, 2001. The consultation addresses

1. National procedures for inter-agency coordination and elevation of issues,

2. National consultation on existing water quality criteria for aquatic and aquatic-dependent species,

3. National research and data gathering plan,

4. Improved consultation procedures for EPA approval of state and tribal water quality standards, and

5. Procedures for coordination in regard to state and tribal NPDES permits.

The national consultation will provide coverage under ESA section 7 for water quality criteria in state or tribal water quality standards. After national consultations have been completed, EPA can approve numeric criteria for protection of aquatic life and aquatic-dependent wildlife in state or tribal water quality standards that are identical to or more stringent than recommended CWA section 304(a) criteria without further consultation except when newly listed species may be affected. Pending the outcome of national consultations, EPA regions can approve criteria in state or tribal standards that are identical to, or are more stringent than, existing CWA 304(a) criteria since this particular action is covered under the MOA between EPA and the Services (EPA memorandum, January 16, 2002, E. Southerland, Director Standards and Health Protection Division). According to EPA's memorandum, regional consultations may occur on an interim basis if consultation on a particular criterion is scheduled for completion late in the national 304(a) consultations. In addition, EPA can make a determination under CWA section 304(c)(4)(B) that a revised or new standard is necessary if there is compelling information that indicates that a listed species will not be protected by proposed state standards.

As part of the national consultations, a regional review team consisting of staff from Region 6 EPA, state EPAs, and the Service was established on April 20-22, 2004 in Dallas, Texas to review and coordinate on upcoming triennial revisions of state water quality standards in Louisiana, New Mexico, Oklahoma, and Texas. Subsequent to the meeting, Region 6 EPA developed a "Backlog Strategy" to identify mechanisms for cooperation and understanding in the water quality standards process between EPA and States and Tribes in Region 6. The strategy's intent is to outline ways in which Region 6 States and Tribes may work together to streamline the process to (1) meet a common goal of standards approvals on new and revised standards within EPA's statutory time frame, and (2) allow continued progress to be made on reducing the current backlog. This includes cooperation on (1) development of water quality standards and implementation procedures, (2) ESA consultations, (3) action on new and revised standards, and (4) applying these processes to resolving the existing standards backlog. The Backlog Strategy is available at http://www.epa.gov/earth1r6/6wq/ecopro/watershd/standard/index.htm.

Information presented in this document is intended in part to serve as technical assistance to Region 6 EPA for the regional review process for surface water quality standards of the State of Texas. Until national CWA 304(a) consultations between EPA and the Service are completed on aquatic life criteria or unless new information becomes available, recommendations made in the document can serve as interim information for conserving federally listed species and their associated habitats in Texas. Specific water quality criteria found in this document are based on (1) water quality parameters known to affect aquatic and aquatic-dependent listed species or (2) water quality criteria currently existing in the TSWQS. Unless specific water quality endpoints for aquatic and aquatic-dependent listed species are known, existing TSWQS criteria are used to approximate criteria for individual species. Water quality criteria are approximated from existing water body segments within the range of a listed species when the species occurs in more than one segment.[11] The most protective criteria from different segments within a watershed are used as default criteria if data are unavailable for segments known to have listed species. When criteria for individual segments with listed species are available, the segment criteria are used. Toxicity for listed species may be assumed to be occurring on an acute or chronic basis if (1) criteria for aquatic life protection have been exceeded as suggested by the TSWQS (except when otherwise indicated by criteria that have been revised under national CWA 304(a) consultations), (2) lethal effects have been demonstrated, or (3) non-lethal effects such as reduced reproduction are observed. Since information and data on water quality pertaining to listed species with narrow habitat ranges are inadequate or non-existent in many cases, only the most conservative water quality criteria with respect to these species should be applied. In the current absence of promulgated criteria for groundwater, the Service recommends that surface water criteria as found in this document should generally be used for protecting subterranean species in groundwater unless more specific information is available. In addition, an antidegradation approach should be implemented for protection of groundwater with these species.

[11] Major surface waters in Texas are classified as segments for purposes of water quality management. A segment is defined by TCEQ as a surface water within an approved planning area that has common biological, chemical, hydrological, natural, and physical characteristics and processes. A four digit code is used to identify individual stream segments by basin. For example, Segment number 1814 represents the Upper San Marcos River (Segment no. 14) in the Guadalupe River Basin (Basin no. 18). Eight coastal basins along the Texas Gulf Coast and the State's extraterritorial waters in the Gulf of Mexico are also classified as segments. Unclassified water bodies include perennial or intermittent streams, ponds, lakes, and reservoirs that are too small to have their own coded designation; however, unclassified water bodies are still referenced according to their associated segment.

SECTION 5

GENERAL CRITERIA AND PROCESSES

5.1 Bioaccumulation

Bioaccumulation and the related processes of bioconcentration and biomagnification refer to processes whereby certain contaminating chemicals accumulate in the tissue of organisms through various routes of exposure. Bioaccumulation refers to the accumulation of a contaminant in tissues of an organism through all routes of exposure, i.e., ingestion, direct contact, etc. (EPA 2000). Bioconcentration is the uptake of water-borne contaminants by an aquatic organism whereas biomagnification is the increase in tissue concentrations of a particular contaminant through food transfers between successively higher trophic levels of organisms (Barron 2003). For aquatic species, bioconcentration is a measure of different rates in uptake and elimination of a contaminant (Barron 2003). Bioaccumulation, bioconcentration, and biomagnification can cause various types of toxicants (heavy metals, organochlorine pesticides, etc.) to accumulate in organisms by several orders of magnitude thereby leading to health impairment or lethality. All three processes may occur in aquatic species; however, bioaccumulation and biomagnification are more likely to affect aquatic-dependent species such as waterfowl (Connell 1989, EPA 2000).

Bioaccumulation and bioconcentration are generally expressed as ratios. A bioaccumulation factor (BAF) or bioconcentration factor (BCF) is the ratio of a chemical's concentration in the tissue of an organism divided by the average concentration of the chemical in the environment (e.g., water in the case of bioconcentration). According to EPA (2000), BAFs and BCFs can be defined as

$$BAF_s = C_t/C_s$$

or

$$BAF_w = C_t/C_w$$

$$BCF = C_t/C_w$$

Where,

BAF_s = bioaccumulation factor for sediment
BAF_w = bioaccumulation factor for water
BCF = bioconcentration factor
C_s = concentration of a contaminant in sediment (mg/kg, dry wt.)
C_t = concentration of a contaminant in the tissue of an organism (mg/kg, dry wt.)
C_w = concentration of a contaminant in water (mg/L)

In addition to non-bioaccumulating criteria, specific criteria for toxic materials that can bioaccumulate or bioconcentrate are listed in Tables 1 and 3 of the TSWQS. As described by TCEQ's guidance document "Procedures to Implement the Texas Surface Water Quality Standards" (Jan. 2003, RG-194 revised), BAFs or BCFs are used in TCEQ's permitting process for discharge of wastewater effluents when no specific numerical criterion for protection of aquatic life has been developed for a particular toxic material. BAFs and BCFs can also be used in deriving site-specific chronic criteria for water quality. The equation for chronic criteria of bioaccumulative toxic compounds used in TCEQ's guidance document is

$$\text{Chronic criteria} = (LC_{50}\text{ of most sensitive species})(0.01)$$

Where,

LC_{50} = the lethal concentration of a substance at which 50 percent of organisms die

A chemical is considered by TCEQ to be (1) bioaccumulative if the BAF or BCF of the chemical is 1,000 or greater and (2) highly bioaccumulative if either the BAF or BCF is 5,000 or greater. In some instances, the octanol-water partition coefficient (K_{ow}) of a chemical may be used to estimate the tendency of the chemical to partition from water to organic media. The K_{ow} for a particular chemical is used in lieu of the BCF or BAF when experimental data are limited.

Recommendations – To help protect aquatic or aquatic-dependent listed species from adverse effects, waters with these species should not be modified by anthropogenic additions of bioaccumulative materials to the extent that toxicity (acute or chronic) is induced for individuals of these species during any life stage. Sediments in these waters should not have concentrations of bioaccumulative materials that can result in acute or chronic toxicity to aquatic organisms or otherwise impair the biological integrity through bioaccumulation. Water categories 1, 2, and 3 should not receive bioaccumulative materials from anthropogenic sources. Only the most protective BAFs or BCFs should be applied in Category 4 waters with populations of listed species when developing criteria for calculation of effluent limitations in permits on a site-specific basis. The mobility of both listed species and prey organisms should be considered in deriving BAFs or BCFs for a particular site; and appropriate species-specific information on toxicology, epidemiology, and exposure should be used in developing the BAF or BCF. Any uncertainty factor used in deriving chronic criteria for BAFs or BCFs should be increased if epidemiological data indicates that populations of a listed species are diseased or relatively unhealthy.

5.2 Biochemical Oxygen Demand

Biochemical oxygen demand (BOD) is a measure of the quantity of oxygen consumed by microorganisms during decomposition of organic matter. Aquatic life may be affected if the concentration of dissolved oxygen in a water body is lowered as a result of high BOD levels. BOD measurements taken over a 5-d period (i.e., a BOD_5) are an indirect measure of biodegradable organic compounds in water and are commonly used to determine the oxygen demand on the receiving water of a municipal or industrial discharge.[12] BOD can be used to evaluate the efficiency of wastewater treatment processes and the effectiveness of measures used in the removal of high organic materials from impaired waters under CWA-mandated Total Maximum Daily Loads (TMDLs).

The TSWQS does not contain criteria directly pertaining to BOD; however, effluent limitations on BOD in permits must be restrictive enough to ensure that the receiving water will meet TSWQS requirements for dissolved oxygen. Some wastewater discharge permits for sensitive watersheds as specified in 30 TAC § 311 may require advanced treatment of carbonaceous BOD (CBOD).[13] Minimum concentrations of dissolved oxygen must be met in Texas surface waters (see **Section 5.6 Dissolved Oxygen and Aquatic Life Uses** below). BOD_5 limits are typically placed in National Pollutant Discharge Elimination System (NPDES) permits for all facilities that have the potential to discharge effluent with significant

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[12] BOD_5 analyses require five days for sample incubation (American Public Health Association 1992). After water samples have been inoculated with microorganisms and saturated with oxygen, the samples are then incubated at 20 ^{o}C for five days in a lightless incubator that precludes microbial photosynthesis. The BOD_5 measurement for a sample is the difference between the pre-incubation DO reading of a sample and final DO reading after five days of incubation.

[13] BOD follows two phases during organic matter decomposition (Spellman and Drinan 2001). The carbonaceous phase of BOD occurs as organic materials are decomposed, and the subsequent nitrogenous phase begins when nitrogenous materials undergo decomposition. Carbonaceous BOD (CBOD) may be determined by (1) subtracting the theoretical equivalent of reduced nitrogen oxidation from uninhibited test results or (2) chemical inhibition of nitrogenous demand (American Public Health Association 1992).

quantities of oxygen-consuming substances into water. To ensure that TSWQS requirements for dissolved oxygen are met in the receiving water, TCEQ uses a modeling process to select BOD_5 limits for individual water bodies.

Recommendations – To help protect aquatic or aquatic-dependent listed species from adverse effects, waters with these species should not have BOD levels that can cause DO to be depressed below DO limits that are recommended in this document or have otherwise been established by the TSWQS for these particular waters.

5.3 Biological Integrity

Biological integrity is a measurement of a water body's ability to support and maintain aquatic biota. The TSWQS defines biological integrity as the species composition, diversity, and functional organization of a community of organisms in an environment relatively unaffected by pollutants. Although the TSWQS does not have numeric criteria for biological integrity, the TSWQS does recommend using publicly available documents such as the latest version of TCEQ's "Receiving Water Assessment Procedures Manual" to assess attainment of aquatic life use with indices of biotic integrity.[14] However, standard metrics used to assess biological integrity may not consider the disappearance of individual species to be significant until a particular community threshold has been reached. Listed species may therefore be inadequately protected when these types of metrics are used to determine biological integrity.

Recommendations – To help protect aquatic or aquatic-dependent listed species from adverse effects, waters with these species should not be modified through the addition of pollutants or through physical alteration to the extent that biological integrity within the receiving waters is adversely affected. Sediments in these waters should not have chemical constituents in concentrations or combinations that will result in acute or chronic toxicity to aquatic organisms or otherwise impair the biological integrity. Waters involving aquatic listed species should have the highest possible indexes of biotic integrity for aquatic organisms such as invertebrates that are characteristic of unimpaired aquatic habitat. The biological integrity of these aquatic communities should be determined by using metrics as found in Appendix B of TCEQ's "Draft Surface Water Quality Monitoring Procedures, Volume 2: Methods for Collecting and Analyzing Biological Community and Habitat Data" (RG-416).[15] Where possible, effects from pollutants or physical alteration on the biological integrity in waters with aquatic or aquatic-dependent listed species should be compared to unimpaired upstream conditions or other appropriate reference sites within the same ecoregion that best represent natural conditions with respect to habitat, water quality, species diversity, watershed land use, and riparian conditions. Assessments for biological integrity from reference sites should be determined from endemic native species rather than non-native species when possible. Permits authorizing discharges to waters supporting aquatic or aquatic-dependent listed species should include a requirement for the discharger to undertake periodic monitoring of receiving water conditions to assess changes in biological integrity. Enhanced monitoring should be implemented in areas with local populations of listed aquatic species if any downward trend occurs in species richness or abundance that cannot be explained by a short-term variation in natural conditions.

[14] Some states have criteria for biological integrity as part of their water quality standards. As an example, the criterion for biological integrity in Florida's water quality standards does not allow benthic macroinvertebrates to be reduced to less than 75 percent of established background levels (FDEP 2005). Benthic macroinvertebrates are assessed according to the number of these organisms that are retained on a U.S. Standard No. 30 sieve after being collected and composited from a minimum of three natural substrate samples. The three samples are taken by using a Ponar-type sampler in a minimum sample area of 225 cm^2.

[15] TCEQ's guidance for water quality monitoring is available at http://www.tceq.state.tx.us/compliance/monitoring/water/quality/data/wqm/mtr/swqm_procedures.

Monitoring should be designed to detect possible water quality deterioration before it reaches a stage that makes significant adverse impacts likely for listed species.

5.4 Critical Low Flow

To protect designated uses of a water body, water quality criteria (both acute and chronic) for aquatic life are based on specific assumptions about the magnitude, duration, and frequency of pollutant exposure. Various design flows for water bodies are used to estimate toxicological effects from the three components of pollutant exposure. Most states use hydrologically based design flows as a basis for implementing water quality criteria (65 FR 4125). Hydrologically based design flows for flowing waters are also known as "extreme value statistic flows" by which the lowest average stream flow for a specified number of consecutive days is statistically determined from historical data taken over a recurring interval of a specified number of years. The design flow used in Texas by TCEQ is the 7Q2, i.e., the lowest average stream flow for seven consecutive days with a recurrence interval of two years as statistically determined from historical data. The 7Q2 for a particular surface water body is the minimum flow to which the TSWQS applies, and effluent limits in wastewater discharge permits in Texas are calculated to maintain the applicable water quality criteria for protection of aquatic life when instream flows are at or above the 7Q2. The 7Q2 is also generally used to determine critical low-flow conditions below which certain criteria in the TSWQS no longer apply. These criteria include

1. Numerical criteria for dissolved oxygen,
2. Numerical criteria for temperature and pH,
3. Numerical criteria for fecal coliform or other bacteriological indicators,
4. Numerical criteria to protect aquatic life from acute toxicity (applied at and above 0.25 x 7Q2),
5. Numerical criteria to protect aquatic life from chronic toxicity, and
6. Requirements to preclude chronic toxicity in whole effluent toxicity testing.

Texas waters may periodically have 7Q2 flows of zero, e.g., streams in west Texas stressed by drought or excessive water withdrawals (surface or ground). The low-flow design for a Texas surface water body is set at 0.1 cfs (cubic feet per second or ft^3/s; 2.8 dm^3/s) when the calculated 7Q2 is equal to or less than 0.1 cfs (e.g., intermittent streams that have a period of zero flow for at least one week during most years). Low-flow design for water bodies listed in Appendix B of the TSWQS cannot be used to (1) regulate flows in water bodies or (2) require that minimum flows be maintained in classified segments. Low-flow designs in the TSWQS are applicable only to river basin and coastal basin waters and do not apply to bays, reservoirs, or estuaries.

Small headwater streams with low flow that serve as habitat for listed aquatic species could receive toxic loadings of pollutants if discharge limits are based on flow that is absent over a period of time. A sustained long-term flow designed under 7Q2 could significantly stress physical and biological characteristics of surface waters with aquatic listed species. Extended time periods for critical low flow designs may be necessary to protect aquatic listed species and their habitat in surface waters that are at, near, or below the naturally occurring 7Q2 flow. When hydrologically based design flows are used, EPA recommends a 1Q10 as the design flow for acute toxicity and a 7Q10 as the design flow for chronic toxicity (EPA 1991).

Flow for the Upper San Marcos River (Segment no. 1814) is currently measured at a USGS gage station (USGS 08170500) that is located at the bridge at University Drive within the City of San Marcos. For application of TSWQS criteria, the river segment has been given a critical low-flow design of 58 cfs (1.6 m^3/s) which is based on a low flow reading in 1956 that may have been influenced by excessive pumping in that year. As a spring-fed system, use of the 58 cfs (1.6 m^3/s) low flow design as the lowest discharge on record (rather than the 7Q2) allows ambient pollutant concentrations to be minimized when wastewater discharge permits are calculated for instream flows and therefore helps protect the five listed species endemic to the river (Comal Springs riffle beetle, fountain darter, San Marcos gambusia, San Marcos salamander, and Texas wild-rice).

Recommendations – To help protect aquatic or aquatic-dependent listed species from adverse effects, design flows used for waters with these species should prevent or minimize critical low-flow conditions below which criteria in the TSWQS are no longer applicable. Discharge permits for waters with aquatic or aquatic-dependent listed species should be based on relatively long critical design flows to account for climatic variability. Permits for discharge into Category 3 waters of the Comal and San Marcos rivers should be based on critical low flows that account for the lowest historical flows on record. Category 4 waters with local populations of listed aquatic species should have permits based on critical low flows of 1Q10 for acute criteria and 7Q10 for chronic criteria.

5.5 Debris

Narrative criteria in the TSWQS require that surface waters must be essentially free of floating debris that can produce adverse responses in aquatic organisms. Some aquatic and aquatic-dependent listed species can be affected by discarded materials or other types of debris in water. Along with naturally-occurring debris, clippings from removal of vegetation in Spring Lake at the head of the San Marcos River may affect Texas wild-rice further downstream in the river by damaging leaves, dislodging roots, or interfering with emergence of reproductive culms (Power 1996). Sea turtles and manatees are potentially affected by debris in water through (1) entanglement or collision with discarded netting and fishing lines and (2) ingestion of plastic debris (Carr 1987, Beck and Barros 1991, Campbell 1995). Ingestion of plastic materials (polystyrene beads, Styrofoam, etc.) and other debris (e.g., tar balls) has been observed in sea turtles along the Texas Gulf Coast (Cole et al. 1990, Plotkin and Amos 1990, Campbell 1995). Sea turtles can ingest debris that is floating on the water surface, suspended in the water column, or lying at the bottom of a water body (Plotkin and Amos 1990). Ingested plastic debris can cause mortality in sea turtles by blocking their digestive tracts (D. Shaver, USNPS, 2005 – pers. comm.). Other potential problems associated with ingested plastic debris in sea turtles include reduction of buoyancy, decreased uptake of nutrients, and increased absorption of toxins (Balazs 1985). Young sea turtles are particularly vulnerable to plastic pellets (eroded plastic materials) and other plastic debris (Carr 1987).

Recommendations – To help protect aquatic or aquatic-dependent listed species from adverse effects, floating or submerged debris and other foreign materials that may be a hazard for these species through ingestion, entanglement, or collision should be eliminated or minimized to the greatest extent possible. For the San Marcos and Comal river systems and for other waters that have aquatic or aquatic-dependent species that may be adversely affected by debris, specific best management practices should be required in permits for point source discharges of stormwater to minimize the presence of debris. A monitoring process for debris (plastic pellets, netting, fishing lines, etc.) should be developed and implemented by agencies responsible for debris-generating activities in waters with highly susceptible listed species (sea turtles and Texas wild-rice) to ensure that debris does not significantly affect these species.

5.6 Dissolved Oxygen and Aquatic Life Uses

Apart from water itself, oxygen is the most limiting parameter of water quality in aquatic habitat (Wetzel 2001). The concentration of dissolved oxygen (DO) in water is a function of temperature, pressure, and salinity (Wetzel 2001). At saturation, more DO is held in cold water than in warm water (Ward 1992). Since DO is necessary for respiration of aquatic organisms, the distribution and composition of aquatic biota are generally determined by DO concentrations in a water body and its bed sediments (Spellman and Drinan 2001). Conditions of low DO may limit the survival of aquatic biota when these conditions persist for extended time periods. Many aquatic insects in lotic waters are relatively intolerant of low DO conditions since regulation of oxygen in these species is directly related to DO concentration in water (Ward 1992). Fish species intolerant of low oxygen levels can become stressed when DO concentrations fall below 5 mg/L (Moyle and Cech 1982). Inadequate DO levels can affect respiration, metabolism, and behavior in amphibians (Hillman and Withers 1979, Boutilier et al. 1992).

Aquifers and spring systems in Texas associated with habitat of aquatic listed species can have different DO levels on an annual basis. Ogden et al. (1986) reported that groundwater with aquatic listed species in the San Marcos area of the Edwards aquifer may have an average 24-h DO concentration as low as approximately 3 mg/L. In a survey of spring systems involving spring-adapted fish species, Hubbs (2001) reported various mean DO levels that ranged from 2.84 mg/L at a spring box associated with Big Bend Springs in Big Bend National Park, Brewster County, to a relatively high DO level of 8.53 mg/L for the spring pool of Finegan Spring which is part of the Devils River watershed in Val Verde County. In comparison, head springs of the Comal and San Marcos rivers had mean DO levels of 5.6 mg/L and 5.4 mg/L, respectively (Hubbs 2001). In some cases, high levels of DO in spring systems with aquatic listed species may reflect a relatively shallow aquifer system (N. Allan, USFWS, 2005 – pers. comm.).

Respiration in most beetle species belonging to the family Elmidae (which includes the Comal Springs riffle beetle) typically requires flowing waters highly saturated with DO (Brown 1987). As a consequence, riffle beetles are most commonly associated with flowing water that has shallow riffles or rapids (Brown 1987). Riffle beetles are restricted to waters with high DO levels due to their reliance on a thin sheet of air (termed the plastron) that is held next to the underside of the body surface by a mass of minute, hydrophobic hairs. The plastron functions as a gill by allowing oxygen to diffuse passively from water into the plastron and replace oxygen absorbed during respiration (Brown 1987). The Comal Springs riffle beetle may be restricted to turbulent, well-aerated areas in Comal Springs and San Marcos Springs since gaseous exchange in the plastron of riffle beetles can actually be reversed in oxygen-depleted waters (Ward 1992). The Comal Springs dryopid beetle also relies on a plastron for respiration, and this beetle species may also be affected by changes in oxygen levels caused by habitat modification (Arsuffi 1993).

The Barton Springs salamander may be experiencing a long-term decline in DO levels within its habitat of Barton Springs in downtown Austin, Texas. Assuming a normalized base flow of 50 cfs (1.4 m^3/s), the DO median concentrations at Barton Springs decreased between 1975 and 2000 by 16 percent from 6.8 mg/L to 5.7 mg/L (Turner 2000). DO levels at Barton Springs have dropped to as low as 2.4 mg/L in previous years (City of Austin 1996). Turner (2004) suggested that salamander counts declined when DO concentrations at Barton Springs fell below 5 mg/L and when flow from the springs fell below 30 cfs.

According to limits set in the TSWQS, DO concentrations in Texas waters must be sufficient to support various aquatic life uses. Aquatic life use categories and requisite DO criteria for classified (numbered) segments are specified in the TSWQS in Appendix A and in Appendix D for other specific waters. Perennial freshwaters that are not specifically listed in these two appendices are presumed to have a high aquatic life use with a mean DO concentration of 5.0 mg/L and minimum of 3.0 mg/L except for Spring time when mean and minimum DO should be 5.5 mg/L and 4.5 mg/L, respectively.[16] An average 24-h DO concentration of at least 2.0 mg/L and an absolute minimum DO concentration of 1.5 mg/L are required by TCEQ to be maintained for intermittent streams when water is present. DO concentrations must be adequate for seasonal aquatic life uses in intermittent streams during the seasons when the aquatic life uses occur. Unclassified intermittent streams with significant aquatic life in perennial pools are designated as having a limited aquatic life use with a corresponding lower DO criterion.

Recommendations – Recommended aquatic life categories and DO concentrations for aquatic or aquatic-dependent listed species are summarized in Table 3 below. As indicated by the TSWQS, surface waters with aquatic or aquatic-dependent listed species generally should have at least a high aquatic life use category. Daily DO concentrations in water categories 2 and 3 should generally be maintained at levels no less than those indicated in Table 3 at all times except under conditions due to natural causes (other than anthropogenic-related causes such as pumpage). For listed species in Category 4 waters, average 24-h DO concentrations should not be less than 4 mg/L except where natural phenomena depress the DO concentration. The Service recommends that the decline in DO at Barton Springs should be studied to determine underlying causes and that possible corrective actions be taken when applicable to prevent discharge permits from causing DO levels to drop below 5.0 mg/L in salamander habitat of Barton Creek.

5.7 Indicator Bacteria

High counts of fecal coliform bacteria may occur in urbanized water systems with aquatic listed species such as the San Marcos River both after heavy rainfall events and during non-rainfall events (Ogden et al. 1986). Criteria for fecal coliform bacteria typically are not included in state water quality standards for the protection of fish and wildlife. However, criteria for fecal bacteria for protection of human health (as indicated in Appendix A of the TSWQS) may indirectly protect aquatic listed species in some water bodies. Human health is adversely affected when fecal bacteria from animal sources (e.g., feces from waterfowl) attain relatively high concentrations in waters used for recreation, drinking, or shellfish harvest. In the past, state water quality standards to protect primary contact recreation from fecal coliform bacteria typically required a geometric mean count that did not exceed 200 colonies/100 mL based on five consecutive samples in a 30 day period with no more than 10 percent of the samples exceeding 400 colonies/100 mL (69 FR 67217). This criterion is currently being modified in water quality standards of states and tribes to reflect more accurate correlations between various indicator bacteria and human health. In the TSWQS, the indicator bacteria for recreation in freshwater is *Escherichia coli* (a subgroup of fecal coliform bacteria) and for saltwater is Enterococci (a subgroup of fecal streptococci bacteria). Fecal coliform bacteria will continue to be used in the TSWQS as a transitional instream indicator of recreational suitability until sufficient data has been accumulated for *E. coli* and Enterococci. Fecal coliform bacteria are also used as a surrogate indicator in effluent limits for wastewater discharges.

Recommendations – To help protect aquatic or aquatic-dependent listed species from adverse effects, fecal indicator bacteria should not exceed bacterial counts protective of human health unless specific information is available for determining appropriate indicator bacteria/fecal coliform counts for a particular listed species.

[16] Separate criteria for DO and associated critical low-flow are used for streams and rivers in Texas that lie east of a line defined by Interstate Highway 35 and 35W from the Red River to the community of Moore in Frio County, and by U.S. Highway 57 from the community of Moore to the Rio Grande. The separate DO criteria and associated critical low-flow values are given in Table 5 of the TSWQS.

5.8 Nutrients

High nutrient levels in water bodies can lead to eutrophication resulting in excessive algal blooms, decreased dissolved oxygen, and other effects that adversely affect biota (Lampert and Sommer 1997, Wetzel 2001). In general, nitrogen and phosphorus are assumed to be the primary nutrients contributing to the nutrient status of lotic waters (Dodds and Welch 2000).[17] Nitrogen is generally considered to be less of a limiting factor in eutrophication processes of inland waters as compared to phosphorus; however, nitrogen in the form of ammonia can be toxic. Sources of nitrogen and phosphorus in water include (1) industrial pollutants, (2) human and animal wastes, and (3) fertilizers used on cropland, residential lawns, and golf courses (Carpenter et al. 1998). Golf courses can potentially cause nutrient pollution of surface waters or groundwater either through over-fertilization or by using effluent (treated municipal sewage) during irrigation. Excess nutrients from confined animal feedlot operations (CAFOs) can impact aquatic ecosystems by contributing to eutrophication, hypoxia (low levels of dissolved oxygen), and outbreaks of toxic microorganisms such as *Pfiesteria piscicida* (Carpenter et al. 1998, EPA 1999b).

Nutrient enrichment in waters from natural and anthropogenic sources can increase primary production by aquatic plants. Nutrient enhancements of aquatic vegetation can cause waters to become supersaturated through excess dissolved oxygen production which can lead to gas bubble trauma in aquatic organisms (Fidler and Miller 1994). High levels of nutrients may also contribute to toxic algal booms in both inland and coastal waters. Along with warm temperatures and salinity, nutrients play a role in causing red tides which are outbreaks of an algal species (*Karenia brevis*) that produces a toxin lethal to many marine species (Hodgkiss and Ho 1997, Cheng et al. 2005). Sea turtles and manatees are susceptible to red tides, and these species may be impacted by red tides that periodically occur along the Texas Gulf Coast. However, the manatee's rare occurrence along the Texas Gulf Coast ordinarily precludes poisoning incidents. Nutrients are also possibly involved in blooms of golden alga (*Prymnesium parvum*) which can cause fish kills in saline inland waters during relatively cold periods (Larsen and Bryant 1998, TPWD 2002). Golden algal blooms have the potential for impacting federally listed fish species since habitat for these species occurs in areas where golden algal blooms have previously caused fish kills (James and De La Cruz 1989, TPWD 2002).

Nontoxic, nutrient-induced blooms of algae periodically occur in the Barton Creek watershed upstream from habitat of the Barton Springs salamander. Elevated nutrient levels in Barton Creek have generally been attributed to effluent wastewater discharge or runoff from residential areas and golf courses (City of Austin 1997). Trend analyses of water quality data from Barton Springs indicate that nutrient levels have increased at the spring complex (Turner 2000, Herrington et al. 2005). In addition to nutrients discharged with the recharge zone of the Edwards aquifer, nutrient inputs in contributing zones of the Edwards aquifer may also affect habitat of the Barton Spring salamander. A report by the City of Austin (City of Austin 2006) suggested that discharge of nutrients into Bear Creek in Hays County from a proposed wastewater treatment plant (WWTP) at a point approximately 7.8 miles (12.6 kms) above the recharge zone of the Barton Springs segment of the Edwards aquifer could potentially change Barton Springs

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[17] Nitrogen and phosphorus are characterized according to a number of chemical forms (American Public Health Association 1992). Total nitrogen (TN) is the sum of nitrate (NO_3), nitrite (NO_2), and total Kjeldahl nitrogen. Total Kjeldahl nitrogen (or TKN) refers to an analytical procedure that involves digestion and distillation of a sample (water, soil, etc.) to determine both organically-bound nitrogen and ammonia (NH_3). Phosphorus in the water column includes soluble reactive phosphorus (SRP), soluble organic or soluble un-reactive phosphorus (SUP), and particulate phosphorus (PP). The sum of SRP and SUP is the soluble phosphorus fraction, and the sum of all phosphorus components is termed total phosphorus (TP). Soluble phosphorus and particulate phosphorus are differentiated by passage through a 0.45 μm membrane filter. The soluble reactive fraction consists mainly of inorganic orthophosphate (PO_4) which is the form of phosphorus that is taken up directly by algae.

municipal pool in Austin from an oligotrophic state to a mesotrophic one thereby increasing nuisance algal conditions and reducing DO up to 1 ppm during low flow periods.

The San Marcos River and possibly the Comal River in central Texas may have phosphorus-limited systems of nutrient cycling. In a water quality study on the San Marcos River, Groeger et al. (1997) suggested that the spring-driven river is a phosphorus-limited system due to high nitrogen-to-phosphorus ratios and the response of algae to added phosphorus in a bioassay experiment. Relatively small additions of phosphorus to this type of water system by effluent discharge from wastewater treatment plants or by surface runoff can greatly increase the potential for plant growth such as algae and thereby affect habitat of aquatic listed species endemic to these rivers.

Narrative criteria in the TSWQS does not allow nutrients from permitted discharges or other controllable sources to impair existing, attainable, or designated uses due to excessive growth of aquatic vegetation. Site specific nutrient criteria, nutrient permit limitations, or separate rules may be established by TCEQ to control nutrients in individual watersheds when appropriate. Some wastewater discharge permits for sensitive watersheds as specified in 30 TAC § 311 are required to include specific phosphorus limits. Nutrients may also be indirectly managed through criteria for low dissolved oxygen (DO).[18] TCEQ is currently developing nutrient criteria for approximately 25 reservoirs in conjunction with the U.S. Geological Survey. These criteria are being considered for proposal in the next triennial revision of the State's water quality standards. The effort is part of a national strategy by EPA to assist the states and tribes in development of numeric nutrient criteria for all surface waters. EPA has published guidance for numeric criteria based on ecoregions. Most states are developing site-specific nutrient criteria, rather than using EPA's eco-regional values.

<u>Recommendations</u> – To help protect aquatic or aquatic-dependent listed species from adverse effects, nutrient concentrations in waters with these species should not be altered so as to cause imbalances in native populations of aquatic flora or fauna. In particular, nutrients should not be in concentrations that will stimulate growth of invasive species, aquatic plants, or algae to the extent that aquatic habitat or the biological integrity is substantially reduced. Numeric criteria for relevant nutrients should be developed and implemented on a site-specific basis whenever nutrient enrichment causes degradation that can impact aquatic or aquatic-dependent listed species. The Comal River, San Marcos River, and Barton Creek in central Texas should have nutrient criteria in the TSWQS to prevent excessive plant growth (including algae) and limit the potential for invasive species. In addition to nutrient concentrations, indicators of nutrient enrichment such as diel oxygen swings, pH spikes, excessive algal growth, and chlorophyll a should also be considered in determining whether waters with aquatic or aquatic-listed species are impaired. Nutrient-impaired waters with aquatic or aquatic-dependent species should be included on the CWA § 303(d) list for developing TMDLs (Total Maximum Daily Loads). An antidegradation evaluation should be required whenever a new or increased loading of nutrients is proposed for discharge into contributing zones or recharge zones of aquifers that provide water for listed species habitat by an existing or new facility or activity, either point source or regulated stormwater. Nutrient inputs into aquatic habitat of listed species from agricultural runoff, industrial effluents, and municipal discharges should be managed to prevent supersaturation from excess oxygen production by aquatic plants.

5.9 pH

The pH in groundwater and non-polluted rivers generally ranges from 6.0 to 8.5 (Hem 1992). The pH in a river generally increases as water in the river moves downstream from the head waters into lower

[18] Since biochemical oxygen demand (BOD) may also be responsible for low DO conditions, both BOD and nutrients must be considered when low DO is observed in a water body.

reaches of the system (Ward 1992). Organic substances such as tannic acid and carbon dioxide cause lower values of pH in water whereas salts such as carbonates and sulfates in soils and bedrock increase the pH (Hem 1992). Photosynthesis in surface water may raise pH up to 9.0 (Hem 1992). The toxicity of chemical constituents in water such as metals is influenced by pH (Rattner and Heath 2003). Extremes in pH can directly affect aquatic organisms, and even relatively small changes in pH can cause significant stress to aquatic organisms since pH is based on a logarithmic scale. Immature stages or eggs of aquatic organisms are potentially more sensitive to changes in pH values than adults. Species of perch and salmonids can be harmed at pHs above 9.0, and a pH above 11.0 is lethal to all species of fish (Connell and Miller 1984).

Some aquatic listed species associated with relatively small habitats in Texas may not tolerate wide pH ranges. Texas wild-rice typically exists only within the relatively narrow pH range of neutral to slightly alkaline conditions associated with the San Marcos River (Poole and Bowles 1999, Power 2002). Change of pH in the San Marcos River could directly influence net photosynthesis in Texas wild-rice (Power and Doyle 2004). In a laboratory study that held $C0_2$ concentration at 0.5 percent of total dissolved inorganic carbon, Power and Doyle (2004) found that net photosynthesis in Texas wild-rice declined linearly to zero as water pH approached 8.7.

Clear Creek gambusia in Menard County, Texas could also be affected by any potential change in pH within its headwater pool habitat of Clear Creek (Hubbs 2001). Although Clear Creek is spring-fed from limestone rock strata, habitat of Clear Creek gambusia in the headwater pool has a neutral pH in the range of 6.9 to 7.5 (Hubbs 2001). The relatively narrow pH range in Clear Creek may help preclude competition by western mosquitofish, *Gambusia affinis* (Campbell 1995, Hubbs 2001). Hubbs (2001) believed that water pH was second in importance only to temperature in separating populations of spring-adapted species of *Gambusia* from stream-adapted *Gambusia* species in Texas.

Although a pH range of 6.5 to 8.5 meets EPA's general criteria for protection of aquatic life, certain aquatic taxa may have different pH requirements in their aquatic environment. In the TSWQS, criteria for pH are designated only for classified waters in Texas. The general range of pH criteria in the TSWQS for these waters is 6.5 to 9.0 which may extend beyond the normal range of pH in waters with sensitive aquatic listed species. In comparison, various studies have indicated general pH ranges of approximately 7.1 to 8.4 for the San Marcos River and 6.9 to 7.8 for the Comal River (Fahlquist and Slattery 1997, Groeger et al. 1997, Slattery and Fahlquist 1997, Hubbs 2001, Saunders et al. 2001, Ging and Otero 2003). Texas wild-rice in particular could be adversely affected by discharge permits that have been set according to pH criteria in the TSWQS that are outside the natural pH range of the San Marcos River.

Recommendations – To help protect aquatic listed species from adverse effects, the pH in waters that have listed species with a high requirement for water quality (Categories 1, 2, and 3) should be maintained on a site specific basis as indicated below in Table 3. Apart from the Comal and San Marcos rivers in Category 3, all Category 1, 2, and 3 waters should not have any discharge of wastewater effluents. Permits for discharge of wastewater or stormwater into the Comal and San Marcos rivers should not allow change in pH beyond natural pH ranges associated with these two river systems. To help reduce the potential for adverse pH effects on Texas wild-rice, the current TSWQS criterion for pH in the Upper San Marcos River segment should be revised to a range of 7.1 to 8.4. The pH criterion for the Comal River should also be revised to a range of 6.9 to 7.8 to protect aquatic listed species associated with this river system. For aquatic listed species in Category 4 waters, the pH should not vary by more than two-tenths of a pH unit above or below natural background for discharges in waters with local populations of these species. Effluent should not be discharged in these waters if the effluent is outside of this pH range. To protect aquatic-dependent listed species in Category 4 waters, narrative language should be added to the TSWQS that prevents pH levels in effluent discharges from fluctuating by more than 1.0 pH unit.

5.10 Salinity

Salinity reflects the concentration of dissolved inorganic solids (i.e., salts such as chlorides or sulfates) in water.[19] Levels of salinity may increase in watershed basins undergoing drought or water withdrawals. Saline produced water that is released during oil field operations may also contribute to salinity of water bodies. Salinity of a water body affects the internal water balance in aquatic organisms and can thereby influence the distribution and diversity of aquatic species. Aquatic organisms may be affected by the composition and ratios of specific ions since certain ions such as potassium and bicarbonate can be relatively toxic in comparison to other ions (American Petroleum Institute 1999). Large variations in salinity concentration over relatively short periods of time can cause stress or lethality in aquatic organisms (Ingersoll et al. 1992). For aquatic organisms exposed to toxicants, salinity has a greater influence on chronic toxicity than it does for acute toxicity (Rattner and Heath 2003). Distribution of fish populations can be directly influenced by salinity (Moyle and Cech 1982).

Through regression analysis, Turner (2000) found that average conductivity increased in habitat of the Barton Springs salamander from 1975 to 1999 during all flow conditions. Median conductivity for base flow at Barton Springs with recharge increased by 14 percent (from 574 μS/cm to 651 μS/cm) during those years (Turner 2000). Increased conductivity at Barton Springs may reflect urban development in the watershed (Turner 2000). Specific dissolved ions such as chloride, sodium, sulfate, and magnesium increase during periods of low spring discharge at Barton Springs and can particularly increase when discharge drops below 40 cfs (1.1 m^3/s) (City of Austin 1997, Chamberlain and O'Donnell 2003). Sunken Garden Springs in the Barton Springs complex tends to have the highest levels of specific conductance which is possibly due to the proximity of its groundwater flow path with the saline "bad-water" line in central Texas (City of Austin 1997). The "bad-water" line is a constantly shifting boundary between potable inland groundwater and highly saline groundwater that extends into central Texas from the Texas Gulf Coast. Under drought-induced conditions, groundwater from the bad-water line potentially can affect springs along the Balcones fault in central Texas including Barton Springs and possibly Comal Springs or San Marcos Springs as well (USFWS 1996, LBG-Guyton Associates 2004).

Individual aquatic listed species endemic to the Pecos River basin in west Texas can have different tolerances for high salinity. Comanche Springs pupfish may tolerate only non-saline to slightly saline conditions in the San Solomon Springs system associated with the Balmorhea area of Reeves County (USFWS 1981, Campbell 1995). In contrast, Pecos gambusia and Leon Springs pupfish tolerate relatively high salinities that occur at Diamond Y Draw in Pecos County. Hubbs (2001) found that salinity ranged from 3.4 to 17.5 ppt (parts per thousand) at various spring outflows of Diamond Y Draw. Pecos sunflower occurs in sub-irrigated, saline soils of ciénegas at Diamond Y Draw and the San Solomon Springs system. In conjunction with environmental factors such as water temperature and pH, relatively high salinity in spring-dependent surface waters in west Texas possibly prevents competition by invasive species with aquatic listed species. High salinity in Diamond Y Draw may prevent largespring gambusia (*Gambusia geiseri*) from competing with the threatened Pecos gambusia (Echelle and Echelle

[19] Although salinity and total dissolved solids (TDS) are used interchangeably, TDS technically includes all soluble constituents dissolved in water whereas salinity involves only the combined concentration of six common cations and anions (calcium, magnesium, sodium, bicarbonate, chloride, and sulfate) that constitute the major constituents of TDS. Salt concentrations in water may be determined (1) directly by chemical analysis or (2) indirectly as specific conductance (electrical conductivity or EC at a specified temperature). The specific conductance of a solution is expressed as µS/cm (microSiemens per centimeter) at 25 °C from which TDS can then be calculated (e.g., 1000 µS/cm EC = 640 ppm TDS at 25 °C). Salinity in aquatic and terrestrial environments is ordinarily approximated by specific conductance rather than TDS analysis.

1980, Campbell 1995). The common sunflower, *Helianthus annuus,* may be unable to compete with the threatened Pecos sunflower in ciénegas in west Texas due to high salinity (Bush and Van Auken 2004).

Alteration or disturbance of natural salinity levels can stress habitats and food sources of listed species. Piping plover habitat on coastal tidal flats may be impacted if emergent halophytic vegetation in the habitat is reduced through continuous inundation with freshwater effluents (Alexander and Dunton 2002). An increase in salinity levels in winter habitat of the whooping crane could impact a primary food source and serve as a potential limiting factor for the crane. Within the Guadalupe estuary along the Texas Gulf Coast, whooping cranes are highly dependent on blue crabs (*Callinectes sapidus*) as a mainstay of their winter diet. Chavez-Ramirez (1996) found that blue crabs constitute 80 to 90 percent of whooping crane diet during the winter. Although whooping cranes can use alternative food sources (clams, frogs, plants, etc.) when crabs are unavailable, the poor nutritive value of these alternative foods can cause cranes to expend fat reserves and undergo a net loss of energy (Chavez-Ramirez 1996). Adult blue crabs are most prevalent in mesohaline areas (5 to 20 ppt) of the Guadalupe estuary along the Texas Gulf Coast (TPWD 2005).[20] Adequate freshwater inflows from the San Antonio and Guadalupe river systems into the estuary are necessary to maintain salinity levels conducive to blue crab populations (T. Stehn, USFWS, 2005 – pers. comm.). To maintain adequate numbers of adult blue crabs in the Guadalupe estuary, Hamlin (2005) concluded that estuarine inflows should be managed to maintain salinity levels of less than 20 ppt. In addition to adverse effects of high salinity on blue crabs, salinity above 23 ppt may impact whooping cranes by causing them to fly inland for freshwater to drink. These daily inland flights have the potential to (1) decrease crane energy reserves, (2) increase stress in cranes by reducing time available for foraging or resting, and (3) allow possible predation of cranes during their stay at inland areas (T. Stehn, USFWS, 2005 – pers. comm.).

TSWQS criteria for total dissolved solids (TDS), chlorides (Cl^-), and sulfates (SO_4^{-2}) are based on ambient data obtained from individual segments associated with a particular river basin. Criteria for the three parameters are expressed in Appendix A of the TSWQS as the maximum annual average for individual segments and are recalculated from at least four annual observations according to the following formula:

$$\text{Criterion TDS, } Cl^-\text{, or } SO_4^{-2} = \bar{x} + t_{(1)\,(0.05)}\,(s_{\bar{x}1\,-\,\bar{x}2})$$

Where:

Criterion TDS, Cl^-, or SO_4^{-2} = the value of total dissolved solids, chlorides, or sulfates for which the annual mean should not be exceeded

$\bar{x}$ = mean of the baseline data

t (1) (0.05) = critical value of the t distribution
= 0.05 for a one-tailed test at n + 4 degrees of freedom

$s_{\bar{x}1\,-\,\bar{x}2}$ = standard error for the mean

Recommendations – To help protect aquatic and aquatic-dependent listed species from adverse effects, the average annual salinity in waters where aquatic and aquatic-dependent listed species occur should be maintained at or below concentrations as indicated below in Table 3. Where a salinity range is not

[20] Male blue crabs typically remain in estuarine areas with relatively low salinity throughout the juvenile to adult stages of their life cycle whereas mature females tend to inhabit areas with higher salinity (USFWS 1986). After mating, fecund females migrate to high salinity regions near the ocean to release their larvae (Hench et al. 2004). Larval stages of the blue crab require high salinity (> 20 ppt) in the estuary-ocean interface to maintain osmolality during development before they can migrate as megalopae to less saline environments in estuaries (USFWS 1986, Forward et al. 2003).

indicated in Table 3, salinity in a discharge should not be increased more than 50 percent above natural background levels for effluent discharges into Category 4 waters. Water categories 1, 2, and 3 should not have any salinity increases due to discharge of effluent. The composition and ratios of specific ions in discharges should not induce acute or chronic toxic effects in aquatic listed species. Inflows and discharges of wastewater or stormwater affecting the Guadalupe estuary along the Texas Gulf Coast should be managed with the objective of maintaining salinity at levels that will protect all stages in the life cycle of the blue crab and the overall ecosystem functioning of the estuary. Continuous inundation of coastal tidal flats by freshwater effluents should be avoided to prevent impacting piping plover habitat.

5.11 Sediment

Sediments are unconsolidated mixtures of materials (sand, silt, clay, gravel, organic debris, etc.) that are either deposited in sedimentary layers in water bodies or occur in the water column as suspended sediments. Sediments in water can physically affect aquatic organisms by abrading or clogging gill structures, smothering eggs, reducing feeding success, altering behavioral patterns, and changing competitive relationships (Ward 1992, Klapproth and Johnson 2000, Schueler 2000). Excessive amounts of suspended sediment can eliminate available habitat or else modify it by (1) reducing light penetration, primary production, and oxygen levels, (2) shifting nutrient dynamics and trophic structures, and (3) changing thermal relationships (Ward 1992). In addition to physical impacts from sediment, aquatic organisms can also be impacted by sediment-borne contaminants. Sediments act as both a sink and as a means of transportation for contaminants (Menzer and Nelson 1980, Ward 1992). Contaminant compounds can be absorbed by sediment in concentrations higher than ambient concentrations in the water column (Mahler and Lynch 1999). Toxic chemicals may be released when sediments are disturbed by dredging operations (Förstner 1990).

High porosity and fracturing of limestone bedrock in the Edwards aquifer allows water and sediments to be rapidly transported to aquifer springs. Sediments carried into karst aquifers by surface runoff can affect overall aquifer water quality by serving as a vector for transport of contaminants and nutrients (Ford and Williams 1994, Mahler and Lynch 1999, Mahler et al. 1999). Contaminants are readily transported into and throughout the Edwards aquifer due to runoff of large amounts of surface-generated sediments that bear a relatively high content of organic carbon and clay (Mahler et al. 1999). Hydrophobic contaminants such as polycyclic aromatic hydrocarbons (PAHs), petroleum hydrocarbons, and some pesticides can be concentrated and transported in sediment by sorption to organic carbon, mobile clays, mobile calcite, and quartz sediment (Mahler and Lynch 1999).

A number of listed aquatic species and their food sources may be directly exposed to sediment-borne contaminants discharging from spring outlets of the Edwards aquifer. Trace metals such as arsenic, cadmium, copper, lead, nickel, and zinc have been found in the Barton Springs habitat of the Barton Springs salamander (City of Austin 1997). Data in the City of Austin's (1997) report indicate that a substantial number of sediment samples that have been taken in the salamander's habitat exceed contaminant criteria for sediments as suggested by EPA (1997) and MacDonald et al. (2000). However, Mahler (2003) found that most trace metals in suspended sediment samples taken at Barton Springs were probably related to the aquifer's natural geochemistry.

Some aquatic listed species in Texas can be affected by excessive sediment deposition in their habitat. The San Marcos salamander, Comal Springs riffle beetle, and Devils River minnow typically require silt-free bottom substrates (e.g., gravel, cobble, or plants) for habitat (USFWS 1995, Bowles et al. 2003, Garrett et al. 2004). Silt and debris deposited by floods can reduce habitat of the Barton Springs salamander to relatively small, silt-free areas immediately adjacent to spring outlets; and deposition of sediment in these areas during flood events may have contributed to periodic declines in salamander populations over the years (City of Austin 1998). In addition to flood-deposited sediment, sediment deposition in habitat of the Barton Springs salamander can also occur from water discharged by the Barton Springs complex in downtown Austin, Texas. Mahler and Lynch (1999) calculated that approximately one metric ton of sediment is discharged from Main Springs over a 24-h period following a 2-inch (5-cm) rainfall event.

Sediment composition and accumulation in the San Marcos River can affect the endangered Texas wild-rice. Poole and Bowles (1999) found that Texas wild-rice stands in the river occur primarily in sandy sediments with moderately coarse to coarse textures and low organic matter. Sediment deposition has eliminated several small stands of Texas wild-rice in the San Marcos River at the river's confluence with Sessom Creek and has impacted several wild-rice stands in the river that lie further downstream from the confluence (J. Poole, TPWD, 2005 – pers. comm.). Increased sedimentation in the San Marcos River is probably due to a combination of flow reduction from dam structures in the river and sediment carried by surface runoff into contributing tributaries of the river's watershed (Earl and Wood 2002).

The TSWQS does not have numerical criteria for sediment; however, narrative criteria in the standards require that surface waters should be essentially free of suspended solids that can produce (1) adverse responses in aquatic organisms or (2) putrescible sludge deposits or sediment layers that adversely affect benthic biota or any lawful uses. Discharge of sediments in wastewater discharges can be controlled on a site-specific basis through the antidegradation policy in the TSWQS. In addition to criteria for nutrients and pathogens, EPA is currently developing a national strategy for development of sediment criteria that can be used as guidance by states and tribes. When necessary, TCEQ may use sediment protective concentration levels for protection of aquatic life that have been developed for ecological risk assessments under TCEQ's program for risk reduction, i.e., the Texas Risk Reduction Program (TRRP). TRRP is used by TCEQ to regulate cleanup and management of hazardous wastes and substances in Texas. As part of the TRRP, TCEQ has developed benchmark concentrations for toxic materials in sediments (other than selenium) that can be used to determine whether such concentrations are safe to aquatic organisms. Sediment benchmarks listed in Table 3-3 of the TRRP may be viewed as NOAELs (No Observed Adverse Effect Levels) since they are based on conservative primary effect levels such as Effects Range-Low (ERL) from Long and Morgan (1990) and Threshold Effects Level (TEL) from Smith et al. (1996). The TRRP rule (30 TAC Chapter 350) can be accessed at http://www.tceq.state.tx.us/rules/indxpdf5.html.

Recommendations – To help protect aquatic and aquatic-dependent listed species from adverse effects, sediment should not impact species habitat to a degree that essential life cycle requirements of listed species are significantly impaired. This includes feeding (e.g., reducing food sources), breeding (e.g., smothering spawning areas), or sheltering (e.g., filling up available niches for cover). Excessive amounts of sediment in species habitat should be minimized to the greatest extent possible. Stormwater permits for point source discharges involving water categories 2 and 3 should be designed with best management practices to limit artificially high flow velocities that can cause stream bank scour and increase sediments through erosion. In addition, sediment should not have chemical constituents in concentrations or combinations that reasonably can be expected to (1) result directly in acute or chronic toxicity to these species, (2) bioconcentrate or bioaccumulate in tissues of these species or their food sources at levels that can impair their health, or (3) otherwise impair the biological integrity of aquatic habitat associated with these species. Toxic materials contained in suspended sediment and discharged effluent waters should not alter concentrations of these materials in bed sediments in such a manner as to adversely affect listed species. For discharge permits that potentially involve Category 2 or 3 waters with aquatic or aquatic-dependent listed species, concentrations of toxic materials in sediments affected by effluent discharges should not exceed ecological benchmarks as listed in Table 3-3 of TCEQ's "Guidance for Conducting Ecological Risk Assessments at Remediation Sites in Texas" (RG-263, December 2001, revised) and reproduced in Appendix B of this document.[21] For determination of alternative benchmarks for toxic materials in sediments, the process outlined in TCEQ's guidance "Determining PCLs for surface water and sediment" (RG-366/TRRP-24, revised, December 2002) may be followed if the alternative benchmark attains a NOAEL. Sediment benchmark criteria in TCEQ's guidance should also be applied to Category 3 and 4 waters with listed species where harmful concentrations of contaminants have built up in sediments over extended periods of time without direct discharge of wastewater effluents.

5.12 Supersaturation

Supersaturation in water is caused when atmospheric gases (nitrogen, oxygen, carbon dioxide, or trace gases) are dissolved in water at concentrations above 100 percent (Bouck 1980, Fidler and Miller 1994).[22] Supersaturated conditions occur when partial pressures of atmospheric gases in solution are greater than their partial pressures in the atmosphere (Fidler and Miller 1994). Dissolved gas supersaturation can result from a variety of man-made and natural causes. Sources of supersaturation include (1) gas entrainment in water discharge from dams and high water falls, (2) mixing of warm-water effluent from cooling facilities of power generating plants with cool receiving water, (3) high levels of O_2 production by aquatic plants, and (4) air lift aeration or gas injection systems used to increase dissolved oxygen in lakes and fish hatchery systems (Fidler and Miller 1994). Supersaturation can also occur in aquifer groundwater and spring discharge waters (Heaton and Vogel 1981, Bouck 1984). Groundwater arising in aquifers, wells, and springs may become supersaturated due to high pressure or an increase in temperature (Fidler and Miller 1994).

Supersaturated water can cause gas bubble trauma in aquatic organisms (Bouck 1980, Colt et al. 1984, Krise and Smith 1993, Fidler and Miller 1994).[23] As part of the etiology of gas bubble trauma, gaseous bubbles accumulate as emboli inside the cardiovascular system or as bubbles in tissues immediately below body surfaces (Fidler and Miller 1994). Death from gas bubble trauma is caused primarily by blockage of the cardiovascular system and possibly by the production of lesions and necrotic tissue that can cause secondary infections (Fidler and Miller 1994). A secondary morphological effect of gas bubble trauma is "popeye" in fish whereby the eyeballs are extruded from the eye socket (Krise and Smith 1993). Although acute lethality for most aquatic organisms generally begins at a supersaturation level of 110 percent, some aquatic species can be affected by supersaturation as low as 103 percent (Cornacchia and Colt 1984, Wright and McLean 1985, Fidler and Miller 1994). At relatively low levels of gas supersaturation, fish can experience bubble formation in the buccal cavity and gut, hyperinflation or rupture of the swim bladder, and low rates of mortality (Colt 1986). Nebeker et al. (1976) suggested that most freshwater invertebrates are less sensitive to gas bubble trauma than freshwater fish; however, certain invertebrate species such as *Daphnia magna* could be more sensitive in comparison.

The endangered Barton Springs salamander may be impacted periodically by supersaturation in its spring habitat in downtown Austin in Travis County. Between January 2002 and June 2002, Barton Springs salamanders in both Upper Barton Springs and Sunken Garden Springs were observed to have gas

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[21] TCEQ's guidance for ecological risk assessment can be accessed at http://www.tceq.state.tx.us/comm_exec/forms_pubs/.

[22] Although supersaturation percentages are commonly used for reporting dissolved gas supersaturation, the preferred method is to express supersaturation in terms of ΔP where ΔP is the excess gas pressure in mm of Hg (Fidler and Miller 1994). Delta P is equal to the combined partial pressures of nitrogen gas, oxygen gas, and water vapor minus the partial pressure of atmospheric pressure, i.e., $\Delta P = pN_2 + pO_2 + pH_2O - pAtm$. Water is supersaturated with dissolved gasses when ΔP is greater than 0.00 mm Hg.

[23] Gas bubble trauma is also known as gas bubble disease; however, the trauma term more accurately describes the pathological condition since pathogenic microorganisms are not involved except as secondary agents.

bubbles occurring throughout their bodies. Twelve of 19 salamanders found in 2002 with bubbles in their bodies were dead or died shortly after being found. In addition, symptoms of gas bubble trauma were also found in other species at Barton Springs including fish, frog tadpoles, crayfish, and beetle larvae (Chamberlain and O'Donnell 2003). These species experienced buoyancy problems, and several fish exhibited the "popeye" morphology associated with gas bubble trauma. Pathological reports on affected animals at Barton Springs indicated that the most likely etiological agent was gas bubble trauma (Chamberlain and O'Donnell 2003). Although other factors such as contaminants or disease could be responsible for the salamander die-off at Barton Springs, supersaturation in the spring water itself may have played a major role in the die-off. During the years of 2002 to 2003 when affected salamanders were found, supersaturation percentages were elevated at all four springs of the Barton Springs complex with a general range of 110 to 115 percent. Upper Barton Spring exhibited the highest supersaturation with up to 125 percent in 2002 and up to 131 percent in 2003. In addition, a monitoring well located along the groundwater flow path to Upper Barton Springs was supersaturated above 160 percent when tested in April, 2002 (J.A. White and D. Johns, City of Austin hydrologist, 2002 – unpublished data).

In addition to Barton Springs, supersaturation can occur at other spring habitats of aquatic listed species in Texas. The senior author of this report observed supersaturation at Comal Springs (113 percent) and San Marcos Springs (102 percent) in April, 2002 (J.A. White 2002 – unpublished data). Potentially, supersaturation occurring in these spring systems could affect resident aquatic listed species (Peck's cave amphipod, San Marcos salamander, etc.). However, further research is needed to clarify what role supersaturation in spring or aquifer habitats in Texas plays in the population dynamics of aquatic listed species.

Although the TSWQS does not have criteria for supersaturation, supersaturation may be controlled on a site-specific basis through the antidegradation policy in the TSWQS. EPA has recommended a water quality criterion of 110 percent for protection of aquatic organisms against supersaturation.[24] The criterion represents the highest level of supersaturation that fish can generally tolerate in shallow water (Weitkamp and Katz 1980).

Recommendations – To help protect aquatic and aquatic-dependent listed species from adverse effects, supersaturation in waters involving these species should be eliminated or minimized to the greatest extent possible. Except under conditions that are attributable to natural causes, water categories 1, 2, and 3 should not have supersaturation levels that can affect any stage of the life cycle for these species or impair biological integrity of their habitat. For Category 4 waters, total dissolved gas should not exceed 110 percent of saturation at any point of sample collection except where natural phenomena cause supersaturation to occur. Nutrient inputs into aquatic habitat of listed species from agricultural runoff, industrial effluents, and municipal discharges should be managed to prevent potential supersaturation from excess oxygen production by aquatic plants. Gas abatement measures (ventilation, mechanical agitation, etc.) should be used to prevent or limit supersaturation by discharge of effluents from being introduced into waters with aquatic listed species. Physical structures such as dams or cooling facilities of power plants should be designed to limit supersaturation in aquatic habitat of listed species, and the Service should be consulted on permits for construction of facilities that potentially could cause gases to supersaturate in waters with these species.

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[24] Gas saturation of 110 percent at sea level is equivalent to $\Delta P = 76$ mm Hg (British Columbia Ministry of Environment 2006).

5.13 Temperature

Aquatic organisms can be greatly affected by water temperature regimes in their habitat. Water temperature can affect the toxicity of various chemicals (Mayer and Ellersieck 1988). Amphibians and reptiles exhibit various physiological and morphological responses to water temperature regimes such as metabolic activity, sex determination, and limb regeneration (Henry 2000, Palmer 2000). Aquatic habitat temperature is one of the most important environmental variables for fish reproduction and is principally involved with gonad development, sperm maturation, ovulation, egg maturation, spawning, and incubation success (Moyle and Cech 1982, Armour 1991). Temperature also affects fish by controlling migration; growth rates; intra- and inter-specific competition; and the ability to resist disease, parasites, and pollutants (Armour 1991).

Some aquatic listed species in Texas are adapted to relatively narrow temperature ranges. Except for periods of rapid recharge from inflows of surface water, species with habitat in the Edwards aquifer (water categories 1 and 2) have relatively constant below-ground temperatures (City of Austin 1997).[25] Temperature in the surface water component of Category 2 waters is directly influenced by spring flow from the aquifer, and only relatively small temperature gradients in surface water typically exist within the narrow habitat range (< 0.5 mile, 0.8 km) of the four species in this category (Barton Springs salamander, Comal Springs dryopid beetle, Peck's cave amphipod, and San Marcos salamander). Norris et al. (1963) suggested that the maximal metabolic rate in the San Marcos salamander was correlated with ambient temperatures characteristic of its spring-fed habitat in Hays County. Spring-dependent listed species in Category 3 waters with habitat extending up to several miles (kms) downstream from the headsprings are adapted to ambient temperatures associated with these waters. Hubbs (2001) believed that different temperature regimes associated with thermally stable springs and thermally variable streams in Texas is a primary factor in keeping spring-adapted *Gambusia* species apart from stream-adapted *Gambusia* species in these waters. Big Bend gambusia competes successfully with western mosquitofish only under constant temperatures in warm spring runs and is less successful in habitats with fluctuating temperatures (USFWS 1984).

As defined by Moyle and Cech (1982), surface waters in Texas are generally in the warm water range of temperature since these waters can exceed 75 to 79 ^{o}F (24 to 26 ^{o}C) for extended periods of time. However, spring water emerging from the Edwards aquifer has consistently cool temperatures ranging from 68 to 73 ^{o}F (20 to 23 ^{o}C) (City of Austin 1997, Groeger et al. 1997, Slattery and Fahlquist 1997, Hubbs 2001). Hubbs (2001) reported that spring water at Phantom Cave Spring in Jeff Davis County in west Texas has an average temperature as low as 57.7 ^{o}F (14.3 ^{o}C). Some aquatic listed species with aquifer or spring-dependent habitat can be affected physiologically by water temperatures higher than the normal range. Norris et al. (1963) observed nearly 50 percent mortality in San Marcos salamanders that were held over a 2-h period under laboratory conditions at a temperature of 86 ^{o}F (30 ^{o}C). Juveniles of the San Marcos salamander experience loss in their ability to right themselves at 93.7 ^{o}F (34.3 ^{o}C) (Berkhouse and Fries 1995). High water temperature particularly affects reproduction in the fountain darter. Bonner et al. (1998) reported that fountain darter reproduction (eggs and larvae) becomes adversely affected under laboratory conditions at water temperatures above 73 ^{o}F (23 ^{o}C) and is significantly affected above 77 ^{o}F (25 ^{o}C). McDonald (2003) found that darter production of eggs and larvae significantly decreased at laboratory water temperatures above 75 ^{o}F (24 ^{o}C). Bonner et al. (1998) and McDonald (2003) both reported that darter reproduction was effectively eliminated at water temperatures of approximately 82 to 86 ^{o}F (28 to 30 ^{o}C). The current TSWQS temperature criteria in the two San Marcos River segments (Upper San Marcos River segment – 80 ^{o}F (27 ^{o}C), Lower San Marcos

[25] As an example, the City of Austin (1997) reported that the temperature of water discharged at Barton Springs in November, 1995, did not vary by more than a degree or two from a constant range of 21 to 21.5 ^{o}C (69.8 to 70.7 ^{o}F) except for periods during the month when heavy rainfall caused rapid recharge of aquifer water.

River segment – 92 ^{o}F (33 ^{o}C)) and the proposed 80 ^{o}F (27 ^{o}C) temperature criterion for the Comal River in the 2000 triennial revision are at levels that potentially could adversely affect aquatic listed species in these systems. The fountain darter in particular could be affected within the two river systems by discharge permits that have been set according to high temperature criteria in the TSWQS.

Specific temperature criteria for classified Texas waters are listed in Appendix A of the TSWQS. The TSWQS does not have numerical temperature criteria for industrial cooling lake impoundments; however, temperatures in such impoundments must be maintained to allow reasonable use of such waters. For discharges involving treated domestic effluent and within designated mixing zones, the maximum that discharge temperatures can be raised above the ambient temperature are

- Freshwater streams –

  5 ^{o}F (2.8 ^{o}C),

- Freshwater lakes and impoundments –

  3 ^{o}F (1.7 ^{o}C), and

- Tidal river reaches, bays, and gulf water –

  4 ^{o}F (2.2 ^{o}C) in fall, winter, and spring;

  1.5 ^{o}F (0.8 ^{o}C) in summer (June, July, and August).

<u>Recommendations</u> – To help protect aquatic listed species from adverse effects, temperatures in waters with these species should be maintained at levels that will not affect any life cycle stage of these species or impair the biological integrity of their habitat. The average annual temperature in waters where these species occur should be maintained at or below temperatures as indicated below in Table 3. The current TSWQS temperature criteria for the Upper San Marcos River segment and the Comal River should be revised to 75 ^{o}F (24 ^{o}C) to help reduce the potential for adverse effects on fountain darter reproduction. There should be no increase in temperature in water categories 1, 2, and 3 due to discharge of treated wastewater. Thermal discharges in Category 4 waters with local populations of aquatic listed species should not alter diurnal or tidal temperature patterns that are normally found in these waters.

5.14 Turbidity

Turbidity is a measure of the amount of suspended particulate material in the water column. The turbidity in a water body is commonly measured by a nephelometer which determines water clarity according to nephelometric turbidity units (NTUs). Since the amount of turbidity in water inversely affects the rate of light penetration in water, photosynthesis in aquatic vegetation is affected by turbidity (Spellman and Drinan 2001). Sediments suspended in water can affect respiratory processes in aquatic organisms by abrading or clogging gill structures, scouring periphyton from rock attachments, decreasing aquatic invertebrate populations, and reducing feeding success (Ward 1992, Klapproth and Johnson 2000, Schueler 2000). Sustained high levels of suspended sediments may shift fish communities toward sediment-tolerant species and may also have an effect on predator-prey relationships by limiting visual abilities of predators (Klapproth and Johnson 2000, Schueler 2000). Schueler (2000) suggested that suspended sediment should not exceed 25 NTUs above natural background for habitats with sensitive fish. However, Henley et al. (2000) found that biotic effects from suspended sediments generally could not be predicted with NTUs due to a lack of correlation between suspended sediment concentrations and nephelometric measurements. Henley et al. (2000) recommended that suspended sediment and nephelometric measurements should be correlated over a range of discharge readings within local watersheds in establishing a baseline for biotic effects.

The endangered Texas wild-rice is a perennial, aquatic macrophyte that is endemic to swift-moving, mid-channel currents of the San Marcos River in Hays County. The species grows in large, clump-like clones that are rooted within sand and gravel of the limestone river bottom. Water depth and light are both important growth factors for Texas wild-rice (Vaughn 1986, Poole and Bowles 1999). Vaughn (1986) found that Texas wild-rice has low growth at depths greater than 4 ft (1.2 m) due to decreased light penetration. Poole and Bowles (1999) suggested that increased turbidity in the San Marcos River over the years has been a contributing factor in the decline of Texas wild-rice stands. The increased turbidity is probably due to (1) various land activities (construction, residential, agriculture, etc.) within the river's watershed, (2) recreational disturbances in the river, and (3) effluent discharges from a municipal sewage system operated by the City of San Marcos and a state fish hatchery (Groeger et al. 1997, Poole and Bowles 1999). Further research is needed to clarify how turbidity in the San Marcos River affects Texas wild-rice.

The TSWQS does not have numerical criteria for turbidity; however, the TSWQS does have a narrative criterion for turbidity as an aesthetic parameter such that waste discharges cannot cause substantial and persistent changes in surface waters from ambient conditions of turbidity. Turbidity may also be controlled by TCEQ on a site-specific basis through the antidegradation policy in the TSWQS.

<u>Recommendations</u> – To help protect aquatic and aquatic-dependent listed species from adverse effects, there should be no increase in turbidity beyond natural causes for water categories 1, 2, and 3 due to discharge of effluent or stormwater. Turbidity should not be increased in the Comal and San Marcos rivers due to swimming, rafting, or other recreational activities. A turbidity criterion for the San Marcos and Comal rivers should be included in the TSWQS to protect Texas wild-rice and fountain darter. Turbidity in Category 4 waters should not be increased more than 50 percent above normal background levels through discharge permits.

Table 3. Aquatic life uses and general criteria for aquatic and aquatic-dependent species listed in Texas. Criteria shown in the table reflect existing TSWQS criteria or general averages derived from data of specific field studies (see references in table footnotes below). A range in criteria is given when species occur in waters that have different aquatic life uses and criteria than specified in the TSWQS. Data in cells or areas that are shaded in grey represent (1) uses and criteria for groundwater in Category 1 waters or (2) differences in recommended uses and criteria for classified and unclassified surface waters as compared to TSWQS. Water quality criteria and recommendations in Table 3 may be subject to revisions according to ongoing national CWA 304(a) consultations between EPA and the Services. The alligator and manatee are not shown in the table due to the SAT (similarity of appearance to a threatened taxon) status of the alligator and rare occurrence of the manatee in Texas coastal waters.

Water Category	T&E Species	Water Body	Aquatic Life Use	Cl^- mg/L	SO_4^{-2} mg/L	TDS mg/L	Dissolved Oxygen *† mg/L (mean or mean/minimum)	pH Range standard units †	Indicator Bact./Fecal Coliform (# colonies per 100 ml)	Temperature °F/°C
1	Texas blind salamander	Edwards aquifer		20	15	300	4.8/3.9	6.7–8.7	97 (fecal coliform only)	71/22
2	Barton Springs salamander‡	Edwards aquifer and Barton Creek (Seg. no. 1430)	High	100	100	500	5.0	6.3-8.5	126/200	71/22
2	Comal Springs dryopid beetle‡	Edwards aquifer, Comal Springs, and Fern Bank Springs	High	50	50	400	5.0	6.9-7.8	126/200	75/24
2	Peck's cave amphipod‡	Edwards aquifer, Comal Springs, and Hueco Springs	High	50	50	400	5.0	6.9-7.8	126/200	75/24
2	San Marcos salamander‡	Edwards aquifer and Upper San Marcos River (Seg. no. 1814)	Exceptional	50	50	400	6.0	7.1-8.4	126/200	75/24
3	Big Bend gambusia	Unclassified springs	High			650	4.6/2.8	6.6-7.7		95/35
3	Clear Creek gambusia	Unclassified springs and pond	High			290	6.6/5.3	6.9-7.6		75/24

Water Category	T&E Species	Water Body	Aquatic Life Use	Cl^- mg/L	SO_4^{-2} mg/L	TDS mg/L	Dissolved Oxygen *† mg/L (mean or mean/minimum)	pH Range standard units †	Indicator Bact./Fecal Coliform (# colonies per 100 ml)	Temperature °F/°C
3	Comal Springs riffle beetle	Upper San Marcos and Comal rivers (Seg. nos. 1814 and 1811)	Exceptional (Upper San Marcos River) or High (Comal River)	50	50	400	6.0 (E) or 5.0 (H)	7.1-8.4 (E) or 6.9-7.8 (H)	126/200	75/24
3	Comanche Springs pupfish	Unclassified springs and spring runs in Balmorhea area	High			3100	4.9/1.9	6.5-7.6		77/25
3	Devils River minnow	Unclassified springs and streams, Devils River, and San Felipe Creek (Seg. nos. 2309 and 2313)	Exceptional or High	50	50	300 (E) or 400 (H)	6.0 (E) or 5.0 (H)	6.9-7.8	126/200	74/23
3	fountain darter	Comal River and both San Marcos River segments (Seg. nos. 1811, 1808, and 1814)	Exceptional (Upper San Marcos River) or High (Comal River and Lower San Marcos River)	50-60	50	400	6.0 (E) or 5.0 (H)	7.1-8.4 (E) or 6.9-7.8 (H)	126/200	75/24
3	Leon Springs pupfish	Unclassified springs and spring runs at Diamond Y Draw	Exceptional			6840	5.7-4.1	6.6-7.7		70/21
3	Pecos assiminea	Unclassified springs and spring runs at Diamond Y Draw	Exceptional			6840	5.7-4.1	6.6-7.7		70/21

Water Category	T&E Species	Water Body	Aquatic Life Use	Cl^- mg/L	SO_4^{-2} mg/L	TDS mg/L	Dissolved Oxygen *† mg/L (mean or mean/minimum)	pH Range standard units †	Indicator Bact./Fecal Coliform (# colonies per 100 ml)	Temperature °F/°C
3	Pecos gambusia	Unclassified springs and spring runs in Diamond Y Draw and Balmorhea area	Exceptional (Diamond Y Draw) or High (Balmorhea sites)			6840 (E) or 3100 (H)	5.7/4.1 (E) or 4.9/1.9 (H)	6.6-7.7 (E) or 6.5-7.7 (H)		70/21 (E) or 77/25 (H)
3	San Marcos gambusia	Upper San Marcos River (Seg. no. 1814)	Exceptional	50	50	400	6.0	7.1-8.4	126/200	75/24
3	Texas wild-rice	Upper San Marcos River (Seg. no. 1814)	Exceptional	50	50	400	6.0	7.1-8.4	126/200	75/24
4	Arkansas River shiner	Canadian River (Seg. nos. 101 and 103)	High	1,050-1,975	540-760	4,500-5,000	5.0	6.5-9.0	200	95/35
4	bald eagle	Classified and unclassified water bodies	Exceptional, High, or Intermediate	50-500	50-250	200-1,200	4.0-6.0 (Classified) or 5.0/3.0 (Unclassified)	6.0-9.0	35 or 126/200	90-95/32-35
4	brown pelican	Classified coastal bays	Exceptional or High				5.0 (E) or 4.0 (H)	6.5-9.0	14 or 35/200	95/35
4	Concho water snake	Classified and unclassified water bodies	High	100-11,000	50-2,500	500-20,000	5.0 (Classified) or 5.0/3.0 (Unclassified)	6.5-9.0	126/200	90-93/32-34
4	green sea turtle	Classified coastal bays, Gulf of Mexico	Exceptional or High				5.0 (E) or 4.0 (H)	6.5-9.0	14 or 35/200	95/35
4	hawksbill sea turtle	Classified coastal bays, Gulf of Mexico	Exceptional or High				5.0 (E) or 4.0 (H)	6.5-9.0	14 or 35/200	95/35
4	Houston toad	Unclassified ponds, lakes, and streams	High				5.0/3.0			
4	interior least tern	Classified and unclassified water bodies	High	150-37,000	150-5,300	600-46,000	5.0 (Classified) or 5.0/3.0 (Unclassified)	6.5-9.0	126/200	93-95/34-35

Water Category	T&E Species	Water Body	Aquatic Life Use	Cl^- mg/L	SO_4^{-2} mg/L	TDS mg/L	Dissolved Oxygen *† mg/L (mean or mean/minimum)	pH Range standard units †	Indicator Bact./Fecal Coliform (# colonies per 100 ml)	Temperature °F/°C
4	Kemp's ridley sea turtle	Classified coastal bays, Gulf of Mexico	Exceptional or High				5.0 (E) or 4.0 (H)	6.5-9.0	14 or 35/200	95/35
4	leatherback sea turtle	Classified coastal bays, Gulf of Mexico	Exceptional or High				5.0 (E) or 4.0 (H)	6.5-9.0	14 or 35/200	95/35
4	Little Aguja pondweed	Unclassified stream	High				5.0/3.0			
4	loggerhead sea turtle	Classified coastal bays, Gulf of Mexico	Exceptional or High				5.0 (E) or 4.0 (H)	6.5-9.0	14 or 35/200	95/35
4	Pecos sunflower	Unclassified wetlands	Exceptional or High				5.0/3.0			
4	piping plover	Classified coastal bays	Exceptional or High				5.0 (E) or 4.0 (H)	6.5-9.0	14 or 35/200	95/35
4	whooping crane §	Classified coastal bays with wetlands	Exceptional				5.0	6.5-9.0	14	95/35

References: Ogden et al. (1986), City of Austin (1997), Fahlquist and Slattery (1997), Groeger et al. (1997), Slattery and Fahlquist (1997), Hubbs (2001), Saunders et al. (2001), Ging and Otero (2003).

* TSWQS dissolved oxygen limits:

1. Dissolved oxygen means are applied at a minimum average over a 24-h period.
2. Daily minima for dissolved oxygen do not extend beyond 8 h per 24-h day. Lower dissolved oxygen minima may apply on a site-specific basis when natural daily fluctuations below the mean are greater than the difference between the mean and minima of the appropriate criteria.
3. Spring criteria to protect fish spawning periods are applied during that portion of the first half of the year when water temperatures are 63.0 to 73.0 °F (17.2 to 22.8 °C).

† Criteria:

E = exceptional aquatic life use

H = high aquatic life use

‡ Surface habitat only

§ Winter habitat only

SECTION 6

CRITERIA FOR TOXIC MATERIALS

6.1 Ammonia

Although ionized ammonia (NH_4^+) is relatively nontoxic to aquatic organisms, the un-ionized form of ammonia (NH_3) is highly toxic (Rattner and Heath 1995). NH_3 is more toxic than ionized ammonia since the un-ionized form can diffuse across epithelial membranes of aquatic organisms more readily as a neutral molecule than the charged ammonium ion (EPA 1999a). Ammonia toxicity is influenced by both pH and temperature due to ionization effects (Rattner and Heath 2003). As pH or temperature increase, acute toxicity to aquatic organisms from NH_3 increases (EPA 1995). Un-ionized ammonia concentrations as low as 50–200 μg/L (ppb) can significantly reduce growth in aquatic animal species (Colt and Armstrong 1981). Aquatic invertebrates are generally more tolerant to ammonia than fish (EPA 1995). High ammonia concentrations can cause mortality, convulsions, and coma in fish (EPA 1995). At low ammonia concentrations, fish can experience (1) reductions in hatching success, growth rates, and morphological development, and (2) pathologic tissue changes in gills, livers, and kidneys (EPA 1995).

Ammonia can be discharged into aquatic habitat of listed species as part of municipal or industrial effluent. However, ammonia may also occur in listed species habitat as a by-product of decomposing wastes. In conjunction with other water quality factors, Garrett et al. (2004) suggested that ammonia may restrict the Devils River minnow to relatively non-impacted habitat within Pinto Creek in Kinney County, Texas.

EPA currently recommends (1) an acute toxicity criterion for ammonia based on pH and presence of fish species and (2) a chronic criterion for ammonia based on pH and temperature (EPA 1999a). EPA (1999a) recommends that a site-specific criterion be developed for ammonia when sufficient data indicate that a listed species at a particular site is sensitive at concentrations below the chronic continuous criterion (CCC). Besser et al. (2005) and Dwyer et al. (2005b) found that cold-water rainbow trout provides more comparable sensitivity as a surrogate test species for the fountain darter than warm-water fathead minnow; therefore, EPA's acute ammonia criterion for protection of salmonids may be more appropriate for the fountain darter in the Comal and San Marcos rivers.

In the TSWQS, ammonia is ordinarily addressed through a requirement for biomonitoring, i.e., whole-effluent toxicity (WET) testing. WET testing for ammonia is generally used for point sources (e.g., municipal outfalls) and may not ordinarily be conducted for nonpoint sources of ammonia in non-urban watersheds. TCEQ can establish a zone of immediate dilution (ZID) for ammonia on a case-by-case basis for point sources of ammonia if appropriate. Some wastewater discharge permits for sensitive watersheds as specified in 30 TAC § 311 may require advanced treatment of ammonia. For permits that have a high potential of adversely affecting federally listed species, TCEQ's guidance document "Procedures to Implement the Texas Surface Water Quality Standards" requires a daily average limit of 3.0 mg/L for ammonia-nitrogen as a condition of the permit. However, the 3.0 mg/L daily average limit for permits may not adequately protect sensitive listed species at high pHs as indicated by EPA's national criterion for ammonia in freshwater (EPA 1999a). In addition, screening models used to determine DO sag for permits can be based on a level of ammonia (e.g., 10 mg/L) that may not preclude direct toxicity for species such as mollusks.

Recommendations – To help protect aquatic and aquatic-dependent listed species from adverse effects, effluent with ammonia should be eliminated or minimized to the greatest extent possible. Water categories 1, 2, and 3 (other than the Comal and San Marcos rivers) should not have ammonia discharged into them. There should be no discharge of ammonia in the Comal and San Marcos rivers unless (1) there is sufficient water volume for dilution to preclude toxicity and (2) consultation with the Service has occurred under section 7 of the ESA. Pending the outcome of national CWA 304(a) consultations between EPA and the Service, the 3.0 mg/L average daily ammonia limit used for listed species habitat in the implementing document of the TSWQS should be revised on an interim basis according to criteria and processes defined in EPA's "Update Of Ambient Water Quality Criteria For Ammonia" and following updates (EPA 1999a). Instream concentrations of ammonia due to factors other than effluent discharges should also not exceed criteria in EPA (1999a). To protect the fountain darter, EPA's acute ammonia criterion for protection of salmonids should be used in the Comal and San Marcos rivers. Ammonia limits at the edge of mixing zones in the Comal River, San Marcos River, and Category 4 waters should be based on daily maximums rather than daily averages, and wastewater discharge permits for these systems should require a testing frequency of three ammonia samples per week. Permits should not allow a ZID for ammonia or for other toxic materials in any waters where aquatic listed species occur. For determination of pH-dependent values of ammonia in the Comal and San Marcos rivers, the fountain darter should be modeled as a salmonid species (rainbow trout) with early life stages present year round. Screening models used to determine DO sag for permits should be based on ammonia levels that will preclude direct toxicity for aquatic species. Permits for Category 4 waters with local populations of listed species should have critical low flows of 1Q10 for acute ammonia criteria and 7Q10 for chronic ammonia criteria.

6.2 Chlorine

Similar to ammonia, chlorine is highly toxic to aquatic organisms. A chlorine concentration as low as 28 μg/L (ppb) is acutely lethal to *Daphnia magna* (EPA 1986). Free chlorine typically does not persist in water bodies due to dissipation into the atmosphere as a gas or rapid reaction with other substances; therefore, the potential for chlorine toxicity in water is relatively short-lived. However, chlorine combined with ammonia or amines can be toxic to some aquatic organisms (American Public Health Association 1992). Chlorine may be released into water bodies from disinfection of municipal sewage discharges and from biocide treatments for industrial cooling systems (Rattner and Heath 2003). Residual chlorine in discharged effluent from secondary wastewater treatment facilities potentially has greater toxicity for resident fish populations than ammonia (Paller et al. 1983). To protect aquatic life, dechlorination may be required to remove residual chlorine from disinfected wastewater prior to discharge from a facility. The extent to which discharge of chlorine from facilities may be impacting listed aquatic species in Texas is not known. Garrett et al. (1992) observed discharge of chlorine into stream habitat of Devils River minnow from a swimming pool system in Kinney County, Texas.

EPA has established an acute criterion of 0.019 mg/L (ppm) and a chronic criterion of 0.011 mg/L for total residual chlorine. In the TSWQS, chlorine is addressed through a requirement for whole-effluent toxicity testing, i.e., biomonitoring. Acute toxicity for whole-effluent toxicity testing is measured by a significant difference in lethal concentration between the control and 100 percent effluent in an acute bioassay test. Lethality in 100 percent effluent may be allowed for chlorine (and ammonia) only when it is demonstrated on a case-by-case basis that immediate dilution of effluent within the mixing zone reduces toxicity below lethal concentrations. However, whole-effluent testing may not accurately reflect actual chlorine toxicity due to loss of chlorine during transport and deterioration of stored samples prior to processing. TCEQ may establish a ZID (zone of immediate dilution) for chlorine on a case-by-case basis when appropriate. For permits that have a high potential of adversely affecting federally listed species, TCEQ's guidance document "Procedures to Implement the Texas Surface Water Quality Standards" requires dechlorination as a condition of the permit.

Recommendations – To help protect aquatic and aquatic-dependent listed species from adverse effects, chlorine should not be present in waters with these species. Dechlorination should be used to remove residual chlorine from disinfected wastewater prior to discharge into waters with aquatic listed species, and any chlorinated effluent should be removed at the "end-of-pipe" without the presence of a ZID. For Category 3 river systems (Comal and San Marcos) and for Category 4 waters with known populations of aquatic listed species, a redundant on-line backup system should be used in conjunction with the primary dechlorination system or else sufficient storage should be available to contain chlorinated water until it can be dechlorinated prior to discharge. Specific measurements for chlorine presence should be performed within 15 minutes of sampling effluent discharge rather than using whole-effluent toxicity testing. Overdosing with sulfite dechlorination agents should be avoided to prevent low levels of DO or pH in discharged effluent.

6.3 Metals

Although trace amounts of some essential metals (e.g., magnesium) are necessary for living organisms, uptake of heavy metals is generally toxic for living organisms. Heavy metals are metallic elements that have an atomic weight greater than sodium (i.e., atomic wt. > 22.9). Heavy metal concentrations in a particular watershed reflect background levels of these metals in soils and bedrock as well as inputs from various anthropogenic sources (industrial processes, vehicle wear, paint flaking, metal corrosion, leaching of paving materials, etc.). Non-essential heavy metals such as cadmium, lead, or mercury do not serve any biological function and are typically highly toxic in various ionic forms. Heavy metals can adversely affect aquatic organisms by affecting their growth, reproduction, development, behavior, metabolism, or survival (Eisler 1988, Pain 1995). Adverse effects from heavy metals occur more commonly in early life stages or in individuals that have had relatively long exposures to these metals (Eisler 1988). The relative toxicity of heavy metals in water is influenced by a number of factors including pH, temperature, hardness, alkalinity, and DO levels (Brown 1968, Bradley and Sprague 1985).[26]

Random sediment samples taken from the San Marcos River by the Service in 2001 had heavy metal concentrations for arsenic, chromium, nickel, and zinc that exceeded sediment benchmark thresholds for heavy metals as established by TCEQ's risk reduction program (J.A. White and P.J. Connor, USFWS, 2001 – unpublished data). Heavy metals have also been detected in sediments and the water column in habitat of the Barton Springs salamander at Barton Springs (Hauwert and Vickers 1994, City of Austin 1997). Hauwert and Vickers (1994) found relatively high levels of lead ($Pb_{dissolved}$ = 0.015 mg/L) in Sunken Garden Springs of the Barton Springs complex. Heavy metal concentrations in sediment at Barton Springs could be toxic to prey species of the Barton Springs salamander. The City of Austin (1997) reported concentrations of several heavy metals (arsenic, cadmium, copper, mercury, nickel, and silver) in sediment at Barton Springs that exceeded threshold effect levels (TELs) as suggested by Ingersoll et al. (1996) for an amphipod prey species (*Hyalella azteca*) of the endangered salamander.[27] Except for lead and zinc, Mahler (2003) believed that metal concentrations in suspended sediments discharged at Barton Springs reflected geologic origins for these metals rather than anthropogenic sources.

Since ionic forms in dissolved metal fractions are more closely associated with impacts to aquatic life, heavy metal criteria in water quality standards has shifted from use of total metal concentrations to

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[26] Hardness is the sum of calcium and magnesium concentrations in water expressed as mg/L of $CaCO_3$.

[27] Sediment TELs have adverse effects for at least 15 percent of benthic (sediment-associated) species. In comparison, sediment PELs (probable effects levels) have adverse effects for at least 85 percent of benthic species.

dissolved metal concentrations.[28] Dissolved metals concentrations are used by the TCEQ except for mercury and selenium. Criteria for heavy metals in the TSWQS generally involve (1) a conversion factor as previously determined by EPA, (2) a water-effects ratio, and (3) a calculation for hardness.[29] The water effects ratio is used to account for potential differences that exist between the toxicity of a pollutant in laboratory dilution water and its toxicity in water at a particular site (EPA 1994, EPA 2001). The water-effects ratio is set to 1 except where data are sufficiently available to justify a site-specific, water-effects ratio.

Recommendations – To help protect aquatic and aquatic-dependent listed species from adverse effects, anthropogenic inputs of heavy metals to waters and sediments with these species should be limited to the greatest possible extent. Water categories 1 and 2 should not have any wastewater effluents discharged into them. Permits for discharge of heavy metals into Category 3 waters of the Comal and San Marcos rivers should be based on critical low flows that account for the lowest historical flows on record. Category 3 waters apart from these two river systems should not have effluent with heavy metals discharged into them. Category 4 waters with local populations of listed aquatic species should have permits for heavy metals based on critical low flows of 1Q10 for acute criteria and 7Q10 for chronic criteria. Sediments in all water categories should not have concentrations of individual heavy metals or combinations of heavy metals that can result in acute or chronic toxicity to aquatic organisms or otherwise impair the biological integrity. The Service should be consulted for development of site-specific criteria of heavy metals in Category 4 waters. Where possible, effects from heavy metals in waters with aquatic or aquatic-dependent listed species should be compared to upstream conditions or other appropriate reference sites in the same ecoregion that are similar with respect to pH, hardness, and sequestration of organic matter.

6.3.1 Mercury

As a heavy metal, mercury has no useful biological function and causes various toxicological effects in organisms including neurotoxicity, mutagenicity, carcinogenicity, and teratogenicity (Eisler 1987a, Wiener et al. 2003). Mercury cycling in the biosphere can be increased through geologic inputs (e.g., volcanic activity) or anthropogenic activities such as combustion of fossil fuels, mining, chlor-alkali plant discharge, and disposal of mercury wastes (e.g., fluorescent lights) (Eisler 1987a, Wiener et al. 2003). Forms of mercury with relatively low toxicity can be biologically transformed in the environment into highly toxic forms; and mercury concentrations in organisms can increase through the processes of biomagnification, bioconcentration, or bioaccumulation (Eisler 1987a, Wiener et al. 2003). The most bioavailable and toxic form of mercury is methylmercury (CH_3Hg^+) which is produced from divalent inorganic mercury (Hg (II)) by sulfate-reducing bacteria in anoxic environments such as sediments in estuaries or lake-bottoms (Wiener et al. 2003, USGS 2005). Aquatic environments have a greater tendency for methylation of mercury and exposure of aquatic organisms than terrestrial environments (Wiener et al. 2003).

The extent to which mercury may be impacting listed species in Texas or posing a threat (if any) is not known. The TSWQS has freshwater criteria for mercury of 2.4 µg/L for acute toxicity and 1.3 µg/L for chronic toxicity (respectively, 2.1 µg/L and 1.1 µg/L for saltwater acute and chronic toxicities). The criteria are based on total mercury concentrations in the water column. Pursuant to section 304(a) of the CWA, EPA currently recommends freshwater criteria of 1.4 µg/L for acute toxicity and 0.77 µg/L for

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[28] Dissolved metals are defined as those metals that can pass through a 0.45 µm membrane filter.

[29] An example of a freshwater acute criterion in the TSWQS is zinc (Zn) = $0.978we^{(0.8473(\ln(\text{hardness}))+0.8604)}$ where 0.978is an EPA conversion factor, w is a water effects ratio, and $e^{(0.8473(\ln(\text{hardness}))+0.8604)}$ is the natural antilogarithm calculation for hardness values of calcium and magnesium.

chronic toxicity (respectively, 1.8 μg/L and 0.94 μg/L for saltwater acute and chronic toxicities). However, EPA's recommended criteria for mercury for states and tribes are based on dissolved mercury concentrations in water. Due to the inability of water-based criteria (dissolved or total) to account for mercury bioaccumulation in tissues of organisms, current criteria in the TSWQS or EPA's recommended criteria under CWA section 304(a) may be inadequate to prevent bioaccumulative effects of mercury on aquatic and aquatic-dependent listed species.

Recommendations – To help protect aquatic and aquatic-dependent listed species from adverse effects, the Service recommends that mercury criteria revised as a result of national consultations between EPA and the Service should be adopted in the TSWQS after promulgation by EPA under CWA section 304(a). A monitoring process should be developed and implemented in areas with listed species and high mercury deposition to ensure that mercury is not significantly affecting listed species and designated critical habitat.

6.3.2 Selenium

Selenium is a semi-metallic trace element with biochemical properties similar to sulfur (Eisler 2000). Although selenium is an essential micronutrient for animal species and some plants, selenium can bioaccumulate and is toxic to many species at elevated concentrations (Ohlendorf 2003). Selenium most commonly occurs in natural waters in two oxidation states – selenite (Se^{4+}) and selenate (Se^{6+}) (Ohlendorf 2003). Selenite is the main form of selenium in waters associated with fossil-fuel extraction, refining, and waste disposal pathways whereas selenate is predominant in waters associated with irrigated agriculture (Skorupa 1998, Ohlendorf 2003). Although selenite is generally considered to be more toxic than selenate for most aquatic taxa, die-offs with birds and fish can occur with selenate as well (Skorupa 1998, Eisler 2000, Ohlendorf 2003). Both selenite and selenate can be made into bioavailable forms by algae and other primary producers (Ogle et al. 1988). Organic forms of selenium such as seleno-methionine and seleno-cysteine are particularly toxic to aquatic species (Moore et al. 1990). Direct exposure to waterborne selenium is only a minor exposure pathway for aquatic organisms in comparison to bioaccumulation (Lemly 1996). Depending on the species and tissues being sampled, fish can have selenium concentrations on the order of 100 to more than 30,000 times the concentration in water (Lemly and Smith 1987). Hazardous bioaccumulations of selenium in food chains have occurred at waterborne selenium concentrations less than 2 μg/L (Pease et al. 1992, Maier and Knight 1994, Lemly 1997). Selenium from agricultural irrigation can bioaccumulate to toxic levels in food chains and poison fish and aquatic-dependent birds (Ohlendorf et al. 1990, Skorupa 1998, Hamilton et al. 2002).

Selenium toxicity in animals is expressed in various forms. The most selenium-sensitive life stage for birds is the embryo which can experience abnormal development and lethality; consequently, selenium concentrations in avian eggs are the best measure of hazard for individual avian species (Heinz 1996). Other effects of selenium poisoning in avian species include reduced growth and survival rates in juveniles, mass wasting, and loss of feathers (alopecia). Selenium effects on fish include mortality, growth impairment, reproductive failure, and teratogenic abnormalities (Garrett and Inman 1984, Hamilton 1998, Lemly 2002b). In addition to causing toxicity as a single stressor, selenium may interact with other stressors in animal species and produce adverse effects such as immune system dysfunction or lower disease resistance (Whiteley and Yuill 1989). Selenium can also act synergistically with other contaminants such as non-seleniferous heavy metals (Ohlendorf 2003).

Although selenium concentrations in surface and groundwater generally do not exceed 1 μg/L (ppb), waters in areas with seleniferous rock outcrops may have higher selenium concentrations (Hem 1992, Presser et al. 1994). Seiler et al. (2003) identified the lower Rio Grande in Texas as having high levels of selenium due to long-distance transportation of selenium from marine sedimentary deposits near the Big Bend area. However, mass-loadings of selenium into aquatic environments are usually associated with process wastewater from oil refineries, irrigation water, or fly ash disposal (Ohlendorf 2003). Fossil fuels contribute selenium to aquatic environment through (1) discharge of oil refinery wastewater, (2) leaching of coal-mining spoils or overburden, (3) deposition from coal combustion, and (4) disposal or leaching of fly ash from coal-fired electrical power plants (Skorupa 1998, U.S. Department of Interior 1998, Ohlendorf 2003). Fish kills and impaired avian reproduction occurred in Texas when selenium-bearing fly ash from a coal-fired electric power plant was discharged into a cooling basin (Garrett and Inman 1984, Skorupa 1998). Runoff from feedlots and discharges from industrial and municipal wastewater treatment plants may also contribute selenium to surface waters (Pease et al. 1992).

In Texas, seleniferous bedrock potentially occurs within formations of Tertiary and upper Cretaceous marine sediments that stretch in a belt from just below the Big Bend area of the Rio Grande on up to northeast Texas (U.S. Department of Interior 1998, Seiler et al. 2003). Relatively small areas of upper Cretaceous marine sediments with potential seleniferous bedrock occur in the Big Bend area in Brewster County and extend northwest between the Rio Grande and Pecos River (U.S. Department of Interior 1998, Seiler et al. 2003). Parts of the Texas Panhandle region may also have seleniferous bedrock depending on the presence of continental sedimentary deposits of Tertiary origin (Seiler et al. 2003). Some aquatic and aquatic-dependent species currently listed in Texas (e.g., Devils River minnow and Houston toad) occur in regions with seleniferous bedrock. The extent to which selenium derived from bedrock poses a threat (if any) to listed species in Texas is not known. More immediate threats to listed species from selenium in Texas waters may occur from (1) oil refineries with restricted discharge areas, (2) stockpiled-seleniferous materials such as fly ash, or (3) selenium-contaminated irrigation water. The Arkansas River shiner in particular could be adversely affected in its Canadian River habitat in the Texas Panhandle by selenium from oil refinery discharges.

Derivation of water quality criteria for selenium is problematical. Although a water-borne selenium concentration of 20 μg/L for acute toxicity has been published by EPA for use by states and tribes in their water quality standards, the criterion may not adequately protect fish and wildlife since a single pulse of selenium into aquatic ecosystems could have long-term effects through bioaccumulation in aquatic food webs (Lemly 1997, Maier et al. 1998). A considerable number of studies and reviews have suggested that adverse effects can occur below the 5 μg/L chronic criterion for water-borne selenium as a result of bioaccumulation (see Hamilton and Lemly 1999). In recent years, several scientific papers (e.g., Canton and Van Derveer 1997, Van Derveer and Canton 1997) have suggested that chronic selenium criteria should be sediment-based and that selenium criteria could be safely increased for lotic systems (streams and rivers). However, this approach may not adequately address lentic water environments such as lakes and reservoirs (Hamilton and Lemly 1999). Further research is needed to determine whether higher selenium levels allowed by sediment-based criteria would increase bioaccumulation in relatively slow-moving reaches in streams or rivers. Due to the inability of water-based criteria to account for bioaccumulative pathways of toxicity, Hamilton (2002) proposed a national chronic criterion for selenium based on 4 μg/g (= ppm or parts per million) whole-body fish tissue (dry weight).

The TSWQS currently has freshwater selenium criteria of 20 μg/L for acute toxicity and 5 μg/L for chronic toxicity. EPA has recently proposed a national tissue-based criterion of 7.91 μg/g (dry weight) for whole-body fish tissue. As part of the criterion, fish tissues would have to be monitored during the winter for exceeding the 7.91 μg/g (dry weight) limit on selenium whenever whole-body fish tissue concentrations exceed 5.85 μg/g (dry weight) during summer or fall. Similar to current waterborne criteria for selenium, the proposed tissue-based criterion of 7.91 μg/g would not be fully protective of wildlife species (Ohlendorf 2003; also see 69 FR 75541).

<u>Recommendations</u> – To help protect aquatic or aquatic-dependent listed species from adverse effects, anthropogenic inputs of selenium to waters and sediments involving these species should be limited to the greatest possible extent. Sediments in these waters should not have concentrations of selenium or

selenium combined with other toxicants that can result in acute or chronic toxicity to aquatic organisms or otherwise impair the biological integrity through bioaccumulation. Due to the potential for selenium to bioaccumulate, the Service recommends that waters with listed species should have the following chronic criteria:

- Water (Lemly 2002a) –

  2 μg/L (total recoverable basis using 0.45 μm filtered samples)

- Sediment, dry weight (Lemly 2002a, Seiler et al. 2003) –

  2 μg/g (= ppm or parts per million)

- Benthic invertebrates, dry weight (Lemly 2002a) –

  3 μg/g

- Fish tissues, dry weight (Lemly 2002a) –

  whole body = 4 μg/g
  liver = 12 μg/g
  ovary and eggs = 10 μg/g

- Aquatic bird tissues, dry weight –

  liver = 10 μg/g (Lemly 2002a)
  eggs = 6 μg/g (U.S. Department of Interior 1998, Seiler et al. 2003, Harding et al. 2005)

Water categories 1, 2, and 3 should not receive selenium from any anthropogenic source. Site-specific criteria developed for sites in Category 4 waters should not threaten or impact local populations of these species or critical habitat. For Category 4 waters, a critical low-flow of 1Q10 should be used for acute criteria of selenium and a 7Q10 used for chronic criteria. The mobility of both prey organisms and listed species associated with a particular site should be considered in deriving chronic criteria for selenium. Appropriate species-specific information in regard to toxicology, epidemiology, and exposure should be used in developing site-specific selenium criteria. Any uncertainty factor used in deriving chronic criteria for selenium should be increased if epidemiological data indicates that populations of a listed species are diseased or relatively unhealthy.

6.4 Pesticides

Pesticides are chemicals that are typically lethal or have debilitating effects for various groups or types of pest organisms. Pesticides that can affect aquatic species include insecticides, herbicides, fungicides, piscicides, and mosquito larvicides. Pesticide toxicity for aquatic organisms may be increased when pesticides occur in mixtures (Anderson and Lydy 2002). In addition to toxicity incurred from pesticide active ingredients, adjuvants (drift retardants, surfactants, etc.) and carrier materials in pesticide formulations may also be toxic for aquatic species (Mayer and Ellersieck 1988, Relyea 2005). Pesticides can degrade into residual byproducts, and toxic transformation metabolites can occur through this degradation process. As an example, the pesticide acephate has relatively low toxicity for most non-invertebrate species; however, a small portion of acephate (< 10 percent) can degrade into a methamidophos residue which is highly toxic to birds and very highly toxic to aquatic crustaceans (Extoxnet 2000a, Extoxnet 2000b).

In addition to lethal toxic threats, there are possible sublethal threats from pesticides such as endocrine disruption. A number of pesticides may act as endocrine-disrupting chemicals (EDCs) including organochlorine pesticides (e.g., endosulfan), atrazine, aldicarb, and vinclozolin (Guillette and Guillette 1996). Several endocrinological studies with the widely-used herbicide atrazine have suggested that hermaphroditism and demasculinization can occur in amphibians under continuous atrazine exposure (Hayes et al. 2002, Hayes et al. 2003, Sullivan and Spence 2003). Tavera-Mendoza et al. (2002) observed a 20 percent reduction of oogonia in ovaries of female tadpoles of the African clawed frog (*Xenopus laevis*) after the tadpoles were exposed for 48 h to atrazine at a concentration of 21 μg/L. Carr et al. (2003) believed that normal environmental concentrations of atrazine found in surface water would not affect metamorphic processes or sex ratios in the African clawed frog. However, Hayes et al. (2003) reported that a concentration of atrazine as low as 0.1 μg/L (ppb) retarded gonadal development and induced hermaphroditism in American leopard frogs (*Rana pipiens*).

Concentrations of pesticide residues in waters closely reflect pesticide use on land (USGS 1999). Pesticide residue concentrations found in the groundwater of the Edwards aquifer are reflective of pesticide use associated with residential, commercial, and industrial land uses in the contributing and recharge zones (City of Austin 1997). In general, residues of various herbicides are the dominant pesticide form in lotic systems associated with agricultural lands whereas insecticide residues are prevalent in urban waters (USGS 1999). Since the 1970s, pesticide use in the U.S. has changed from highly persistent, bioaccumulative organochlorine pesticides such as DDT and cyclodienes (e.g., dieldrin) to less persistent, non-bioaccumulative pesticides such as organophosphates and carbamates (Hill 1995). Only a small number of relatively non-persistent organochlorine pesticides (e.g., endosulfan) are currently in use. However, residues of highly persistent organochlorine pesticides remaining in water body sediments still have the potential to impact aquatic life (Blus 2003).

The extent to which listed species and their habitats in Texas may be affected by pesticides is unknown. Aquatic and aquatic-dependent listed species in Texas are exposed to pesticides primarily as a result of runoff of pesticide residues from land applications in agricultural or urban areas. In some instances, listed species may also be exposed to pesticides due to (1) spray drift, (2) groundwater discharge, or (3) direct application of aquatic pesticides such as piscicides, aquatic herbicides, or mosquito larvicides. A coauthor of this report (P.J. Connor, USFWS 1996 – unpublished data) found a dithiocarbamate fungicide present at approximately 0.1 mg/L (ppm) concentrations in four random samples obtained from urbanized upper reaches of the Comal River. Trace amounts of diazinon, carbaryl, simazine, atrazine (up to 0.56 μg/L), and deethylatrazine (a degradative metabolite of atrazine) have been detected in spring discharge water in habitat of the Barton Springs salamander for a period of several days after a stormwater runoff event (Mahler and Van Metre 2005). The salamander species may be exposed to these pesticides during rainfall pulse events through various pathways including (1) dermal absorption through semi-permeable skin and (2) sensitive stages of eggs or larvae. Further research is needed to determine whether limited periodic exposure to pesticides has any adverse effect (e.g., endocrine-disruption) on the Barton Springs salamander, its prey, or its habitat.

Due to a limited set of EPA-promulgated criteria for individual pesticides, the TSWQS currently lists criteria for only 14 organochlorine pesticides (including 2 endosulfan isomers), 5 organophosphates, and a single example each of a carbamate, substituted urea, and organotin pesticide. Of the 14 organochlorine pesticides listed in the TSWQS, only 7 of these (dicofol, endosulfan, heptachlor, lindane, methoxychlor, mirex, and pentachlorophenol (PCP)) are currently registered for use. Additional pesticides are addressed in the TSWQS through a requirement for whole-effluent toxicity (WET) testing. However, there may not be adequate controls for pesticides in certain discharge permits since permit limits have not been established in the TSWQS for toxic levels of pesticides. In addition, WET testing is typically used only for point sources of effluent discharge (e.g., municipal outfalls) and for nonpoint (diffuse) sources such as stormwater runoff in urban areas. WET testing is generally not conducted in non-urbanized watersheds with heavy pesticide use such as agricultural lands.

Recommendations – To help protect aquatic or aquatic-dependent listed species from adverse effects, waters with these species should not be modified by pesticides to the extent that (1) toxicity is induced during any life stage of these species or (2) the prey base for these listed species or the biological integrity of the habitat water body become impaired. Concentrations or combinations of pesticides that can result in acute or chronic toxicity to aquatic organisms (including bioaccumulation) should be eliminated or minimized to the greatest extent possible. Aquatic listed species in water categories 1, 2, and 3 should not be exposed to pesticides through discharged effluent, and exposure for these species to pesticide residues in surface runoff or groundwater discharge should be eliminated or minimized to the greatest extent possible. Pesticides occurring in discharged effluent, surface runoff, or groundwater discharge should not threaten or impact individuals of local aquatic or aquatic-dependent listed species or critical habitat in Category 4 waters. A monitoring process should be developed and implemented in watersheds with aquatic listed species and heavy pesticide use to ensure that pesticides are not significantly affecting listed species and designated critical habitat. The Service recommends that TCEQ consider the presence of aquatic or aquatic-dependent listed species in developing its coordinated monitoring schedule and that sites with these species be given priority for ambient toxicity testing.

6.5 Petroleum Hydrocarbons

Petroleum hydrocarbons are complex mixtures of alkanes, cycloalkanes, and aromatic hydrocarbons primarily derived from fossil fuel deposits and secondarily from vegetative sources.[30] These types of hydrocarbons can adversely affect aquatic organisms through toxic activity, alteration of water chemistry, reduction of light, decline in food availability, and smothering of habitat (Albers 2003). Petroleum hydrocarbons and petroleum by-products can contaminate water bodies or wetlands with listed species through (1) runoff from roads or paved areas or (2) spills, effluent discharge, or seepage of petroleum from oilfield activities and oil refining.

Due to the onsite presence of an oil and gas field, listed species (Leon Springs pupfish, Pecos gambusia, Pecos assiminea snail, and Pecos sunflower) found in ciénega habitat of Diamond Y Draw in Pecos County are particularly vulnerable to spills or seepage of petroleum hydrocarbons and produced water. Hauwert and Vickers (1994) found petroleum hydrocarbons in one of four spring habitats (Sunken Garden Springs) of the Barton Springs salamander during two separate collections. Habitat of the whooping crane could be impacted by oil spills or fuel leakage from boating traffic on the nearby Texas Gulf Intracoastal Waterway.

The TSWQS currently does not have aquatic life criteria for petroleum hydrocarbons; however, numerical criteria in the standards for petroleum-related contaminants such as phenanthrene may indirectly pertain to petroleum. In addition, a narrative criterion in the TSWQS requires that surface waters must be maintained such that oil, grease, or related residue cannot produce a visible film of oil or globules of grease on the surface or coat the banks or bottoms of the watercourse; or cause toxicity to man, aquatic life, or terrestrial life.

Recommendations – To help protect aquatic or aquatic-dependent listed species from adverse effects, waters with these species should not be modified by petroleum hydrocarbons or petroleum by-products to the extent that (1) toxicity is induced for individuals of the species during any life stage or (2) biological

[30] Alkanes are straight or branched carbon chains with the generic chemical formula of C_nH_{2n+2}.

integrity of the water body is impaired. Sediments in these waters should not have concentrations of petroleum hydrocarbons or petroleum by-products that can result in acute or chronic toxicity to aquatic organisms.

6.6 Pharmaceuticals and Other Organic Wastewater Contaminants

Many chemicals used involved with urban activities (medical facilities, domestic households, industrial manufacturing, etc.) can pass directly through wastewater treatment processes into aquatic environments with little or no treatment (Halling-Sorensen et al. 1998). Effluent from nonpoint sources (e.g., cropland) generally does not have treatment before reaching a water body except for natural processes of filtration, degradation, etc. In addition to other contaminants (heavy metals, fecal pathogens, etc.), effluent can contain organic materials that can act as hormone mimics or otherwise disrupt normal endocrine function in organisms. Effluent contaminants such as pesticides (e.g., atrazine), industrial chemicals (e.g., polychlorinated biphenyls), and pharmaceuticals can act as endocrine-disrupting chemicals (EDCs) (Colburn et al. 1993, Guillette and Guillette 1996, Hemming et al. 2001). Animal species exposed to EDCs may experience decreased reproductive success, defeminization/demasculinization, abnormal thyroid function, and immunological impairment (Guillette and Guillette 1996).

The extent to which pharmaceuticals and other organic wastewater contaminants pose a threat (if any) to listed species in Texas is not known. Aquatic or aquatic-dependent listed species may be exposed to EDCs through runoff from nonpoint sources or effluent discharges from municipal or industrial wastewater treatment plants. Within the Barton Creek watershed, spring habitat of the Barton Springs salamander may receive effluent with EDCs from septic tank fields, broken sewage pipeline systems, and runoff from areas treated with pesticides or irrigated wastewater. Although potential endocrine disruptors and other sublethal contaminants may not be present continuously in salamander habitat springs, these contaminants could possibly affect the species under relatively short exposure periods during susceptible life stages. The TSWQS does not have criteria for pharmaceuticals or other organic wastewater contaminants. EPA is currently undertaking research on the effects of EDCs on fish and wildlife species.

Recommendations – To help protect aquatic or aquatic-dependent listed species from adverse effects, waters with these species should not be modified by pharmaceuticals and other organic wastewater contaminants to the extent that normal endocrine functioning is disrupted for individuals of these species during any life stage. Sediments in these waters should not have concentrations of these contaminants that can result in chronic sublethal toxicity to aquatic organisms or otherwise impair the biological integrity. Water categories 1, 2, and 3 should not receive pharmaceuticals and other organic wastewater contaminants from any source. Specific effluent testing for EDCs should be required in discharge permits that can affect aquatic listed species in Category 4 waters, and areas in these waters that have effluent discharges with EDCs should be monitored for potential effects on these species. Morphological anomalies, abnormal growth rates, reproductive failures, and other similar pathological effects occurring in listed species should be studied to determine whether EDCs may be affecting them on a sublethal basis.

6.7 Polychlorinated Biphenyls, Dioxins, and Furans

Polychlorinated biphenyls (PCBs), dioxins, and furans are halogenated, aromatic hydrocarbons that have a basic benzene ring structure coupled with chlorine substitution (Rice et al. 2003). PCBs were used as insulating or cooling agents in transformers and capacitors until manufacturing was banned in 1979 (Eisler 1986). Dioxins and furans are chemically related to PCBs and are the contaminant by-products of manufacturing processes that have been released into the environment through combustion or degradative processes (Rice et al. 2003). Various congeners (isomers) of the three chemicals can be highly persistent, bioaccumulative, and biomagnifying (Rice et al. 2003). Toxicological effects from PCBs, dioxins, and furans include lethality, mutagenic defects, reproductive failure, wasting, immunosuppression, and disruption of the endocrine system (Eisler 1986, Rice et al. 2003).

Aquatic or aquatic-dependent listed species may be exposed to PCBs, dioxins, and furans in sediment deposited in water bodies or wetlands serving as habitat. Two randomly collected sediment samples taken from the Comal River by the Service in 2001 had PCB concentrations (respectively, 39.2 μg/g (ppm) and 113 μg/g, dry weight) that exceeded the sediment benchmark threshold of 34.1 μg/g, dry weight, established for PCBs in TCEQ's' risk reduction program (J.A. White and P.J. Connor, USFWS, 2001 – unpublished data). The most probable sources of PCBs in the Comal River were electrical-generation facilities formerly located near the river. The extent to which PCBs, dioxins, or furans pose a threat (if any) to listed species in Texas is not known.

The TSWQS currently has freshwater aquatic life criteria for PCBs of 2.0 μg/L (ppb) for acute toxicity and 0.014 μg/L for chronic toxicity (respectively, 10 μg/L and 0.03 μg/L for acute and chronic PCB toxicity in seawater). Since PCBs are no longer being manufactured, the acute PCB criterion in the TSWQS may no longer exist. The TSWQS does not have aquatic life criteria for dioxins or furans although the standards do have human health criteria for these PCB-related organochlorines.

Recommendations – To help protect aquatic or aquatic-dependent listed species from adverse effects, water bodies or wetlands with these species should not be modified by *in situ* concentrations of PCBs, dioxins, or furans to the extent that toxicity (acute or chronic) is induced for individuals of these species during any life stage. Sediments in these waters should not have concentrations of PCBs, dioxins, or furans that can result in acute or chronic toxicity to aquatic organisms or otherwise impair the habitat's biological integrity through bioaccumulation or biomagnification. Monitoring should be included in discharge permits when PCBs, dioxins, or furans can potentially be discharged into waters with listed species.

6.8 Polycyclic Aromatic Hydrocarbons

Polycyclic aromatic hydrocarbons (PAHs) are a special type of petroleum hydrocarbon composed of two or more benzene rings that have been fused together (Eisler 1987b). PAHs are primarily derived as by-products of fossil fuel combustion and can accumulate in areas with high levels of hydrocarbon combustion such as highway corridors, railroads tracks, and coal-burning electrical plants (Eisler 1987b, Albers 2003). They also occur naturally in environments as a result of volcanic activity, forest fires, and microbial biosynthesis (Eisler 1987b). PAHs can cause lethality, impaired reproduction, reduced growth and development, and tumors or cancer in animal species (Albers 2003). Population numbers and community composition of freshwater invertebrates can be changed by the presence of PAHs (Albers 2003). PAHS generally do not biomagnify in food chains due to the ability of organisms to metabolize PAHs rapidly (Eisler 1987b).

The extent to which PAHs may be affecting aquatic or aquatic-dependent listed species in Texas waters is not known. These species and their prey can be exposed to PAHs in water bodies or wetlands serving as habitat. Random sediment samples taken from the Comal and San Marcos rivers by the Service (J.A. White and P.J. Connor, USFWS, 2001 – unpublished data) had concentrations of total PAHs and individual PAHs (benzo(a)anthracene, benzo(a)pyrene, chrysene, flouranthene, and pyrene) that exceeded (1) sediment benchmark thresholds for PAHs in TCEQ's risk reduction program and (2) Probable Effect Levels (PELs) in sediments as suggested by MacDonald et al. (2000). Relatively high PAH concentrations in the Comal and San Marcos rivers are possibly related to the nearby presence of highway and railroad corridors in the cities of New Braunfels and San Marcos. However, another possible source of PAHs in urban areas is coal-tar sealants that are used to seal parking lots. These particular pavement sealants have been derived as a by-product of coal-tar waste streams in industry and are commonly used in urban areas (Mahler et al. 2005). In comparison to PAHs derived from sources such as highway or railway corridors, use of coal-tar sealants on pavement in urban areas has a greater potential for adversely affecting aquatic species. Mahler et al. (2005) found that PAHs in runoff particles of coal-tar sealants had mean concentrations 65 times higher than the mean concentrations from unsealed asphalt and cement lots. Bryer et al. (2006) reported that coal-tar sealant PAHs (total) in concentrations of 30 and 300 ppm produced stunted growth, slower development, or even lethality in tadpoles of the African clawed frog as compared to the control concentration (0 ppm) and a low concentration of 3 ppm. Coal-tar PAHs from sealants used on parking lots in Austin, Texas, may be deposited in habitat of the Barton Springs salamander during flood events and have the potential to adversely affect the listed species or its prey base. Relatively high concentrations of PAHs have been detected in sediments of two small drainages that discharge into Barton Creek just above Barton Springs municipal pool in the City of Austin (City of Austin 1997, Mahler et al. 2003). The apparent source of PAHs in the two drainages is a coal-tar sealant that has been eroded from paved surfaces in the upper part of the two drainages (Mahler et al. 2003). The City of Austin (1998) reported PAH concentrations in samples collected from bed sediments in Barton Creek and the municipal pool following a flood in October, 1994, that potentially could have been toxic to an amphipod prey species (*Hyalella azteca*) of the Barton Springs salamander as indicated by sediment effect concentrations listed in Ingersoll et al. 1996. However, Mahler (2003) found that PAHs in suspended sediments discharged from Barton Springs after a rainfall event were below sediment guidelines established in MacDonald et al. (2000). The Barton Springs Salamander Conservation Fund which is administered by the Austin Community Foundation is currently funding a study to examine toxicological effects on salamanders by coal-tar sealant PAHs.

The TSWQS currently has aquatic life criteria only for a single PAH (phenanthrene) which is set at 30.0 µg/L (ppb) for both acute and chronic toxicity in freshwater (respectively, 7.7 µg/L and 4.6 µg/L for acute and chronic toxicity by phenanthrene in seawater).[31] The standards do not have PAH criteria for sediments.

<u>Recommendations</u> – To help protect aquatic or aquatic-dependent listed species from adverse effects, waters with these species should not be modified by concentrations of PAHs to the extent that toxicity (acute or chronic) is induced for individuals of these species during any life stage. Sediments in these waters should not have concentrations of PAHs that can result in acute or chronic toxicity to aquatic organisms or otherwise impair the biological integrity of the habitat. Inputs of PAHs into water categories 1, 2, and 3 should either be eliminated or minimized to the greatest extent possible. Monitoring should be included in discharge permits when there is a potential for PAHs to be discharged into Category 4 waters with listed species. Waters with aquatic listed species that have a high level of PAH inputs should be monitored for potential non-lethal effects in resident vertebrate species such as significantly abnormal growth or reproduction.

6.9 Radiological Substances

Radiological substances are materials that generate radioactivity into the environment. Radiation is defined for regulatory purposes as consisting of (1) ά, β, γ, or X-rays; (2) neutrons; or (3) high-energy atomic particles such as electrons or protons (Eisler 1994). The regulatory definition does not include radio waves or light (visible, infrared, or ultraviolet). Substances with radioactivity can enter aquatic environments from natural sources, runoff from contaminated land areas, and accidental releases from

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[31] The water quality standards of Florida have freshwater criteria for total PAHs of ≤ 0.0031 µg/L annual average. Total PAHs are derived from concentration totals for acenaphthylene, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(ghi)perylene, benzo(k)fluoranthene, chrysene, dibenzo-(a,h)anthracene, indenol(1,2,3-cd)pyrene, and phenanthrene.

nuclear facilities or activities (Meyers-Schöne and Talmage 2003). Although radioactivity can produce somatic and genetic effects in aquatic organisms, adverse effects at the population or community levels in aquatic environments have not been observed (Meyers-Schöne and Talmage 2003). The extent to which radiological substances pose a threat (if any) to aquatic or aquatic-dependent listed species in Texas is not known.

In the TSWQS, the discharge of radiological substances is not allowed to exceed amounts stipulated by TAC Chapter 336 relating to Radioactive Substance Rules. To determine radioactivity associated with surface water, filtered samples of dissolved minerals are measured for radioactivity in accordance with EPA's current methodology. Impacts of radioactive discharges in the surface waters are evaluated by TCEQ according to a University of Texas report (June 30, 1960) entitled "Report on Radioactivity – Levels in Surface Waters – 1958-1960." Specific impacts to aquatic listed species from radiological substances in surface water or groundwater in Texas may not necessarily be prevented by the approach outlined in the TSWQS since the University of Texas report primarily addresses human health impacts.

Recommendations – To help protect aquatic or aquatic-dependent listed species from adverse effects, waters with these species should not be modified by concentrations of radiological substances to the extent that toxicity (acute or chronic) is induced for individuals of these species during any life stage or otherwise impairs biological integrity of their habitat. At a minimum, radioactive materials in ground or surface waters with aquatic or aquatic-dependent listed species should not exceed amounts stipulated by the Radioactive Substance Rules in TAC Chapter 336 unless alternative site-specific standards for these substances have been adopted by the TCEQ. The lowest practical level should be maintained for radioactive materials not specified in TAC Chapter 336. Any development of site-specific radiological criteria for waters with aquatic listed species should include consideration of uncertainty factors, exposure, bioaccumulation, population factors, consumption factors, and availability of toxins.

6.10 Soaps and Detergents

Soaps are salts (typically sodium) of long-chain fatty acids whereas detergents generally consist of surfactants and other components such as bleaches, chelating agents, fabric softeners, enzymes, and optical brighteners (Hart 1991). The presence of soaps and detergents in waters involving the Comal Springs riffle beetle and Comal Springs dryopid beetle could potentially affect respiratory processes in the two species. Both beetle species rely on the respiratory mechanism of a plastron which is a thin sheet of air that is held next to the underside of the body surface by a mass of minute, hydrophobic hairs (Brown 1987, Arsuffi 1993). The plastron functions as a gill by allowing oxygen to diffuse passively from water into the plastron and replace oxygen absorbed during respiration. The two listed beetle species may be impacted by the presence of soaps and detergents in water since these chemicals can alter plastron functioning (Brown 1987).

Recommendations – To help protect the Comal Springs riffle beetle and Comal Springs dryopid beetle from adverse effects, waters with these species should not receive soaps, detergents, or other similar cleaning agents from any source. The Service should be consulted when cleaning agents (soaps, detergents, etc.) are used on developed sites near waters associated with these species.

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Table 4. TSWQS criteria and recommendations for toxic materials in Texas waters with aquatic and aquatic-dependent listed species. Criteria in the table reflect existing criteria in the TSWQS except where recommended alternatives (shaded in grey) are indicated. Water quality criteria and recommendations in the table may be subject to revisions according to ongoing national CWA 304(a) consultations between EPA and the Service. All values are in μg/L except where otherwise noted.

Parameter	Freshwater Acute Criteria	Freshwater Chronic Criteria	Saltwater Acute Criteria	Saltwater Chronic Criteria
Aldrin	3.0	---	1.3	---
Aluminum (d)	991w	---	---	---
Ammonia	See recommendations in **Section 6.1 Ammonia** above.			
Arsenic (d)	360w	190w	149w	78w
Cadmium (d)	0.973we $^{(1.128(\ln(\text{hardness})) -1.6774)}$	0.909we $^{(0.7852(\ln(\text{hardness})) - 3.490)}$	45.4w	10w
Carbaryl	2.0	---	613	---
Chlordane	2.4	0.004	0.09	0.004
Chlorine	See recommendations in **Section 6.2 Chlorine** above.			
Chlorpyrifos	0.083	0.041	0.011	0.006
Chromium (Tri) (d)	0.3160we $^{(0.8190(\ln(\text{hardness})) + 3.688)}$	0.3160we $^{(0.8190(\ln(\text{hardness})) + 3.688)}$	---	---
Chromium (Hex) (d)	15.7w	10.6w	1,090w	49.6w
Copper (d)*	0.960we $^{(0.9422(\ln(\text{hardness})) -1.3844)}$	0.960we $^{(0.8545(\ln(\text{hardness})) -1.386)}$	13.5w	3.6w
Cyanide (free)	45.8	10.7	5.6	5.6
4,4'-DDT	1.1	0.001	0.13	0.001
Demeton	---	0.1	---	0.1
Dicofol	59.3	19.8	---	---

Table 4 continued,

Parameter	Freshwater Acute Criteria	Freshwater Chronic Criteria	Saltwater Acute Criteria	Saltwater Chronic Criteria
Dieldrin	2.5	0.002	0.71	0.002
Diuron	210	70	---	---
Endosulfan I (alpha)	0.22	0.056	0.034	0.009
Endosulfan II (beta)	0.22	0.056	0.034	0.009
Endosulfan sulfate	0.22	0.056	0.034	0.009
Endrin	0.18	0.002	0.37	0.002
Guthion ® (azinphos methyl)	---	0.01	---	0.01
Heptachlor	0.52	0.004	0.053	0.004
Hexachlorocyclohexane (lindane)	2.0	0.08	0.16	---
Lead (d)	$0.889we^{(1.273(\ln(\text{hardness})) -1.460)}$	$0.792we^{(1.273(\ln(\text{hardness})) -4.705)}$	133w	5.3w
Malathion	---	0.01	---	0.01
Mercury §	2.4	1.3	2.1	1.1
Methoxychlor	---	0.03	---	0.03
Mirex	---	0.001	---	0.001
Nickel (d)	$0.988we^{(0.846(\ln(\text{hardness})) + 3.3612)}$	$0.997we^{(0.846(\ln(\text{hardness})) +1.1645)}$	118w	13.1w
Parathion (ethyl)	0.065	0.013	---	---

Table 4 continued,

Parameter	Freshwater Acute Criteria	Freshwater Chronic Criteria	Saltwater Acute Criteria	Saltwater Chronic Criteria
Pentachlorophenol	$e^{(1.005(pH) -4.830)}$	$e^{(1.005(pH) -5.290)}$	15.1	9.6
Pesticides	See recommendations in **Section 6.4 Pesticides** above.			
Petroleum hydrocarbons	See recommendations in **Section 6.5 Petroleum Hydrocarbons** above.			
Pharmaceuticals and other organic wastewater contaminants	See recommendations in **Section 6.6 Pharmaceuticals and Other Organic Wastewater Contaminants** above.			
Phenanthrene	30	30	7.7	4.6
Polychlorinated biphenyls (PCBs)[‡]	2.0	0.014	10	0.03
Polycyclic aromatic hydrocarbons (PAHs)	See recommendations in **Section 6.8 Polycyclic Aromatic Hydrocarbons** above.			
Radiological substances	See recommendations in **Section 6.9 Radiological Substances** above.			
Selenium	20	4 µg/g #	564	136
Silver, as free ion	0.8w	---	2w	---
Soaps and detergents	See recommendations in **Section 6.10 Soaps and Detergents** above.			
Toxaphene	0.78	0.0002	0.21	0.0002
Tributlytin (TBT)	0.13	0.024	0.24	0.043
2,4,5 Trichlorophenol	136	64	259	12
Zinc (d)	$0.978we^{(0.8473(\ln(hardness))+0.8604)}$	$0.986we^{(08473(\ln(hardness))+0.7614)}$	92.7w	84.2w

* In designated oyster waters, an acute saltwater [marine] copper criterion of 3.6 [4.37] micrograms per liter is applied outside of the mixing zone of permitted discharges, and specified mixing zones for copper do not encompass oyster reefs containing live oysters.

† Compliance is determined using the analytical method for cyanide amenable to chlorination or by weak acid dissociable cyanide.

[‡] Calculated as the sum of seven PCB congeners: 1242, 1254, 1221, 1232, 1248, 1260, and 1016.

§ Mercury criteria are based on total concentrations.

µg Se/g whole-body fish tissue, dry weight

(d) Indicates that the criteria for a specific parameter are for the parameter's dissolved portion in water. All other criteria are for total recoverable concentrations, except where noted.

e Indicates the antilogarithm of the natural logarithm with base e = 2.71828… Natural logarithms (ln) are $\log^e$.

w Indicates that a criterion is multiplied by a water-effects ratio in order to incorporate the effects of local water chemistry on toxicity. The water-effects ratio is equal to 1 except where sufficient data are available to establish a site-specific water-effects ratio. The number preceding the w in the freshwater criterion equation is an EPA conversion factor.

SECTION 7

ANTIDEGRADATION

Under the CWA, states and tribes are required to have an antidegradation policy as part of their water quality standards [40 CFR § 131.6].[32] Antidegradation refers to actions that are taken to maintain existing uses and water quality in waters of a state or tribal area. A three-tiered approach is used by EPA in requiring states to set minimum requirements for antidegradation [as defined in 40 CFR § 131.12]. The three tiers for antidegradation are

Tier 1 Protects existing water uses and the water quality necessary to protect those uses;

Tier 2 Maintains and protects water quality in waters that exceed levels necessary to support propagation of fish, shellfish, and wildlife, and recreation in and on the water. A lowering of water quality in Tier 2 waters is allowed only after the state finds that after full satisfaction of the intergovernmental coordination and public participation provisions of the state's continuing planning process that lower water quality is necessary to accommodate important economic or social development in the area in which the waters are located; and

Tier 3 Protects outstanding national resource waters (ONRWs) including high-quality waters within or adjacent to national parks and wildlife refuges, state parks, wild and scenic rivers designated by law, and other designated areas of exceptional recreational or ecological significance. Increases in pollutants that could cause degradation of water quality are not allowed in ONRWs.

The antidegradation policy and implementation procedures of the TSWQS are applicable to actions that increase the pollutant loading in waters of the State including wastewater discharges, total maximum daily loads (TMDLs), waste load evaluations, actions related to man-induced nonpoint sources of pollutants, etc. In the TSWQS' antidegradation policy for Tier 1, existing uses and water quality sufficient to protect those existing uses must be maintained. Degradation of waters that exceed fishable/swimmable quality is not allowed under Tier 2 unless a lowering of water quality is necessary for important economic or social development.[33] ONRWs with requisite Tier 3 protections have not been designated for any water body in Texas. Limits for permits issued under section 402 (NPDES – National Pollutant Discharge Elimination System) or section 404 (dredging and filling) of the CWA are evaluated in accordance with the TSWQS' antidegradation policy. In the "Procedures to Implement the Texas Surface Water Quality Standards" (Jan. 2003, RG-194 revised), an increase in permitted loading of less than 10% over the loading allowed by an existing discharge permit is not considered to constitute potential degradation if (1) the increase will attain all water quality standards, (2) the aquatic ecosystem in the area is not unusually sensitive to the pollutant of concern, and (3) the discharge is not relatively large.

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[32] In a January 27, 2005 memorandum, EPA stated that ESA consultations will no longer be conducted with the Service or NOAA NMFS on antidegradation policies in water quality standards of states or tribes. The decision was based on the lack of discretion that EPA has in disapproving an antidegradation policy in a state's water quality standards that meets the requirements of 40 CFR § 131.12.

[33] Degradation is defined in the TSWQS as a lowering of water quality by more than a *de minimis* extent, but not to the extent that an existing use is impaired. Fishable/swimmable waters are defined as waters that have sufficient quality to support propagation of indigenous fish, shellfish, and wildlife and recreation in and on the water. Guidance for determining which water bodies exceed fishable/swimmable quality is found in the standards implementation procedures.

Recommendations – To help protect aquatic and aquatic-dependent listed species from adverse effects, no degradation of surface water quality by artificial sources of pollutants should be allowed such that adverse effects from degradation could rise to the level of take of listed animal species, adverse modification of designated critical habitat, or jeopardy of listed plant species pursuant to the ESA. Water quality criteria in the TSWQS should be periodically reviewed to (1) determine whether additional criteria or more stringent criteria are necessary for protection of listed species and (2) evaluate the need for additional data upon which to base the determination. The criteria should take cumulative impacts on listed species into account. Review processes for antidegradation should have an additional screen for waters with aquatic and aquatic-dependent listed species. To enhance protection for specific waters involving listed species, Category 4 waters should be evaluated at least at the Tier 2 level during antidegradation reviews; and an evaluation at the Tier 3 level of antidegradation should be given to all other water categories (1, 2, and 3). Water categories 1, 2, and 3 should have no further degradation by point or nonpoint sources of discharge. The Service recommends that a strict application of antidegradation provisions should be used for discharge permits involving waters with aquatic or aquatic-dependent species. Any increased loading of pollutants to waters with these species allowed by discharge permits should be considered to constitute degradation unless it can be demonstrated that a lower level of water quality will not have any harmful effect on individuals of these species occurring in the area. The Service should be consulted as part of the process of determining whether the presumption of no effect from increased pollutant loading has been adequately rebutted.

7.1 Mixing Zones and Zones of Initial Dilution

States and tribes have the discretion to include mixing zones as part of their water quality standards. A mixing zone (as defined by the TSWQS) is the area contiguous to a discharge where mixing with receiving waters takes place and where certain criteria applicable to the receiving water can be exceeded providing that conditions of acute toxicity to aquatic organisms are prevented. The purpose of a mixing zone is to allow implementation of less costly controls for pollutants in a given water body without posing major risks to designated uses. Some mixing zones may have a zone of initial dilution (ZID) which is a small area at the immediate point of discharge where initial dilution with receiving water occurs and which may not meet certain criteria applicable to the receiving water. Mixing zones and associated ZIDs are required not to preclude free passage of migratory fish or other migratory aquatic organisms. Due to the possibility of water quality criteria being exceeded in the receiving water, mixing zones and zones of dilution can have adverse effects for aquatic listed species. Mixing zones and ZIDs that allow acute or chronic criteria for toxic materials to be exceeded at discharge points can potentially cause take of aquatic or aquatic-dependent listed species. For waters involving federally designated critical habitat, mixing zones and ZIDs may also represent an “adverse modification” under the ESA if primary constituent elements are affected.

In the TSWQS, numerical acute criteria for toxic substances and acute total toxicity levels for biomonitoring of discharge effluent may be exceeded in a ZID at discharge points but there cannot be any lethality to aquatic organisms. The TSWQS also allows acute criteria to be exceeded below extremely low conditions of stream flow (one-fourth of critical low-flow conditions). Numerical chronic criteria and chronic total toxicity levels (as determined from biomonitoring of effluent samples) may also be exceeded inside mixing zones and below critical low-flow conditions in State waters with designated or existing aquatic life uses. The TSWQS limits the size of a ZID in streams and rivers to 60 ft (18.3 m) downstream and 20 ft (6 m) upstream from the point of discharge with a volume of less than 25 percent of the stream flow at or above the 7-d, 2-yr (year) low-flow (7Q2). ZIDs in lakes and reservoirs are restricted by the TSWQS to a 25-ft (7.6 m) radius, and a limit of a 50-ft (15.2 m) radius is used for ZIDs in bays, tidal rivers, and estuaries.

Recommendations – To help protect aquatic and aquatic-dependent listed species from adverse effects, there should be no discharge of treated wastewater in water categories 1 and 2. The Service should be consulted for mixing zones in the Comal and San Marcos rivers, and all other Category 3 waters apart from these two river systems should not have effluent discharges. Mixing zones should be prohibited for discharges within Category 4 waters in areas with documented occurrences of any listed species unless rigorous scientific analysis with well-established protocols (e.g., ASTM protocols) determines on a site-specific basis that adverse effects to individuals of the species or their associated habitat will not occur. Conditions within mixing zones should never rise to a level where adverse effects to individuals of listed species may occur. Discharge permits should not allow (1) ZIDs in any waters where aquatic listed species occur, (2) adverse effects for the overall biological integrity of waters involving listed species or constituent elements of designated critical habitat, or (3) attraction of undesirable aquatic organisms or dominance of nuisance species outside of the mixing zone. Chronic criteria in the TSWQS should not be exceeded in mixing zones involving critical habitat areas of listed species. Mixing zones should also not be authorized if available evidence (based on toxicity, exposure, etc.) reasonably demonstrates that discharged pollutants may bioaccumulate, bioconcentrate, biomagnify, or persist in sediments, water, or biota.

7.2 Total Maximum Daily Loads

Under section 303(d) of the CWA, states are required to identify waters that do not meet the state's water quality standards and establish Total Maximum Daily Loads (TMDLs) that can be used to address sources of water quality impairment for these particular waters. A TMDL specifies the amount of pollutants that need to be reduced to meet state water quality standards and allocates responsibilities for pollution control among the various sources of the pollutant in a watershed including both point and nonpoint sources. The watershed management program in Texas is implemented by

1. Setting standards for surface water quality;
2. Taking measurements of the condition of surface waters;
3. Assessing the data to determine status and to identify any impairments;
4. Taking action to prevent pollution through limits on discharge of wastewater, and to restore water quality when preventive action fails;
5. Evaluation of progress and adjustment or formulation of plans.

Potentially, the TMDL program in Texas may help maintain or recover listed species by restoring adequate conditions of water quality in their habitat. Degradation of water quality from pollution has been cited as a threat to the continued existence of a number of aquatic species listed in Texas such as the Arkansas River shiner, Little Aguja pondweed, and aquatic species associated with the Edwards aquifer. Populations of listed species affected by impaired water quality in their habitat may not adequately recover until the pollutant causing impairment is removed as a limiting factor.

Recommendations – To help protect aquatic and aquatic-dependent listed species from adverse effects, a screen should be used in TMDL developmental processes to identify waters known to provide habitat of these listed species. When degradation is noted in these waters, there should be an enhanced procedure to determine whether impairment from specific pollutants is affecting resident listed species and whether corrective action should be taken prior to the point when critical levels of water quality drop below the applicable numerical standard. Waters on the CWA section 303(d) list of TMDLs that contain aquatic or aquatic-dependent listed species or designated critical habitat should be ranked as a high priority for control of specific pollutants. Site-specific strategies should be developed in TMDLs to address impaired water areas with local populations of listed species or critical habitat. Delisting of an impaired water body should also consider whether the impairment has sufficiently been eliminated to the point that harmful effects on individuals of a listed species no longer exist.

7.3 Use Designations and Use Attainability Analyses

Water quality standards for states and tribes are required under the CWA to have various "uses" that allow (1) protection and propagation of aquatic organisms (fish, shellfish, etc.) and wildlife (water-related animals such as ducks), (2) recreation, (3) public water supplies, and (4) purposes such as agriculture. Water quality criteria (both numeric and narrative) in state water quality standards are designed to protect and support a particular use. Existing uses are uses that were designated for waters on or after November 28, 1975 which cannot be modified or changed unless a use requiring more stringent criteria is added. Designated uses are those uses specified in water quality standards for each water body or segment whether or not those uses are being attained (i.e., goals). Attainable uses are additional uses that may be achievable in a water body. A use attainability analysis (stream or engineering survey) is required to make determinations for the appropriate use of a particular water body.

Currently, the San Marcos River above the river's confluence with the Guadalupe River has two classified segments, i.e., the Upper San Marcos River segment and the Lower San Marcos River segment. The Upper San Marcos River segment runs from a point 1.0 km (0.6 miles) upstream of the confluence of the Blanco River in Hays County to a point 0.7 km (0.4 miles) upstream of Loop 82 in the city of San Marcos (including Spring Lake). The Lower San Marcos River segment runs 1.0 km (0.2 mile) above the river's confluence with the Blanco River down to the river's confluence with the Guadalupe River. Five aquatic listed species are endemic to the upstream segment; however, two of these species (fountain darter and Texas wild-rice) also exist in the lower segment. Critical habitat for Texas wild-rice exists in both segments. As indicated in Table 3, the two segments of the San Marcos River have designated uses and criteria for contact recreation, aquatic life, and domestic water supply that can be incompatible for adequate protection of aquatic listed species in this river system (e.g., temperature criteria for protection of the fountain darter).

The Comal River also has designated uses and criteria that are inadequate for protection of aquatic listed species as shown in Table 3. The Comal River is currently designated in the TSWQS as Segment No. 1811 which runs from the confluence with the Guadalupe River in Comal County to Klingemann Street in New Braunfels. The headwaters of the Comal River have been impounded to form Landa Lake. Flow in the Comal River below Landa Lake is split between the original channel of the river and an artificial channel (called the new channel) that has Dry Comal Creek as a tributary. In addition to hydrologic differences with single flow reaches of the Comal River, the two channels (approximately, 1.6 mile or 2.6 km in length) have distinct hydrologic regimes and potential uses that are controlled by (1) spring flow from Comal Springs, (2) runoff from tributaries, (3) a municipal stormwater system, (4) diversion and discharges from a water amusement park, and (5) five water gates each ranging from 2 to 4 ft (0.6 to 1.2 m) in width. The two channels of the Comal River eventually converge approximately 330 ft (100 m) above Clemens Dam before flowing downstream to the river's confluence with the Guadalupe River.

<u>Recommendations</u> – To help protect aquatic and aquatic-dependent listed species from adverse effects, waters or segments known to provide habitat within existing ranges of these listed species should be considered to be ecologically sensitive and should have the most beneficial uses associated with them. In those instances where waters with these species are classified for multiple uses and have different criteria applied for each use, the criteria to protect the most sensitive use should be applicable. The Service recommends that a designated use of an "Ecologically sensitive water" be developed for the TSWQS to resolve potential conflicts between current TSWQS and criteria necessary for protection of aquatic or

aquatic-dependent listed species.[34] The Service also recommends that a designated use for aquatic life protection be provided in the TSWQS for segments recharging the Edwards aquifer in addition to the current designated use for protection of domestic water supply.

Reviews of use designations and use attainability analyses for relevant waters should be initiated whenever the Services (USFWS or NOAA NMFS) list an aquatic or aquatic-dependent species in Texas or when critical habitat is designated. Use attainability analyses for waters should also include an evaluation for listed species. A determination should be made as to how current uses for a water body are justified with respect to resident listed species in situations where recovery of a listed species in that particular water body is currently limited by water quality conditions. A reclassification of segments and uses should be considered when a more restrictive use is necessary to protect an ecological system that has an aquatic listed species.

The Comal River and Upper San Marcos River segment in the TSWQS should be reclassified into new segments to provide designated uses and criteria that are protective of aquatic listed species. The Upper San Marcos River segment should be reclassified into two segments with the upper segment occurring from the uppermost reaches of Spring Lake down to the river's confluence of Willow Spring Creek. The lower segment of the San Marcos River should run from Willow Spring Creek's confluence down to 1.0 km (0.6 miles) above the river's confluence with the Blanco River. The Comal River should be reclassified into four segments with appropriate uses and criteria: (1) Landa Lake, (2) the new channel of the Comal River, (3) the old channel of the Comal River, and (4) Comal River proper that would run from the confluence of the old and new channels down to the river's confluence with the Guadalupe River.

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[34] As an example, an "ecologically sensitive water body" is designated in the Arkansas water quality standards as a beneficial use for segments known to provide habitat within the existing ranges of threatened, endangered or endemic species of aquatic or semi-aquatic life forms.

SECTION 8

IMPLEMENTATION OF WATER QUALITY CRITERIA FOR FEDERALLY LISTED SPECIES IN TEXAS

8.1 Texas Pollutant Discharge Elimination System

Under the CWA, all point sources of wastewater must obtain a permit which regulates discharge of pollutants into waters of the United States.[35] The permits are issued in accordance with the National Pollutant Discharge Elimination System (NPDES). Either EPA or states with EPA-approved programs are authorized to issue NPDES permits which can be issued to individual dischargers or a group of dischargers with similar terms and conditions under a general permit. Pollutants in stormwater are regulated with permits issued under the NPDES Stormwater Program for activities involving MS4s (Municipal Separate Storm Sewer Systems), industry, and construction.

Since inception of the Texas Pollutant Discharge Elimination System (TPDES) in September 1998, NPDES permits for discharge of pollutants from most point sources and regulated stormwater into Texas waters are administered by TCEQ. A biological opinion was issued by the Service's field office in Austin on September 14, 1998, for Region 6 EPA's authorization of the TPDES program by the State of Texas. Stipulations in the biological opinion for the TPDES program are found in Appendix C below. Since authorization of the TPDES program, Region 6 EPA may only comment on proposed TPDES permits or object to a TPDES permit. Region 6 EPA now only consults with the Service on permits it proposes to issue such as off-shore permits in the Gulf of Mexico. Region 6 EPA still retains NPDES permitting and enforcement authority for activities regulated by the Texas Railroad Commission including processing, storage, and transportation facilities that involve oil and natural gas.

Specific information on the permit application review process of the TPDES program is found in TCEQ's guidance document "Procedures to Implement the Texas Surface Water Quality Standards" (Jan. 2003, RG-195 revised). The guidance document discusses implementation of TSWQS criteria with respect to federally listed species and outlines the screening for these species during the permit application process. According to the list of segments and USGS Hydrologic Unit Codes (HUCs) provided in the September 14, 1998 biological opinion and the Service's "Hydrologic Database for Federally Listed and Candidate Species in Texas," TCEQ screens permits for segments known to have listed species and then notifies the Service via the Notice of Application and Preliminary Decision which is sent after the permit has been drafted. Supplementary Permit Information Forms (SPIFs) are also sent by TCEQ to notify the Service of impending permit actions. Before issuing a permit, TCEQ determines whether the permit should have additional limitations due to listed species. TCEQ's evaluations include the distance from the discharge point to the water body with a listed species, the amount of discharge, and the potential for impacting the listed species. Permits involving the Edwards aquifer are also evaluated by TCEQ for effects on listed species associated with the aquifer. For permits that have a high potential of adversely affecting federally listed species, TCEQ currently requires dechlorination and a daily average ammonia-nitrogen limit of 3.0 mg/L. Additional actions may be required by TCEQ for TPDES permits to address Service concerns.

[35] The term "point source" refers to discharge from confined, discrete conveyances (e.g., a pipe outfall) whereas a "nonpoint source" involves discharge from diffuse pollution sources that lack a single point of origin (e.g., runoff from cropland, forest land, or construction sites).

Recommendations – A number of facilities in Texas currently discharge into habitat with aquatic and aquatic-dependent listed species. For renewal of discharge permits or establishment of new permits, the Service recommends that applicants

1. Determine whether federally listed species or their critical habitats are present in or near the project area through surveys or other assessments,

2. Determine whether the permit is likely to affect individuals of any listed species or designated critical habitat in or near the discharge area,

3. Determine whether the permit can be modified to avoid adverse effects, and

4. Work with the Service or NOAA National Marine Fisheries Service to modify the project and take other actions (e.g., Habitat Conservation Plans) if adverse effects on the species are likely.

All TPDES permits (including stormwater discharge permits) that involve aquatic or aquatic-dependent listed species should incorporate measures for pollution prevention, waste reduction, and best management practices adequate to protect water quality. A determination should be made in the permit process that biological opinions previously issued by the Service with respect to water quality for listed species do not indicate adverse impacts for proposed or existing projects such as construction of a wastewater treatment plants. Discharge permits should consider the anticipated impact of any proposed lowering of water quality into habitat of listed species, and practical strategies should be implemented for pollutant loads in effluent (e.g., effluent diffusers) such that the expected impact of the discharge to listed species and critical habitat is minimized including any expected attraction of a listed species or an invasive species to the effluent. Non-domestic wastewater discharges should provide a comparably stringent level of treatment as determined by TCEQ.

Water categories 1 and 2 should not be permitted for receiving discharge of wastewater from any source. Discharge permits for the Comal and San Marcos rivers in Category 3 should require consultation with the Service under section 7 of the ESA. All other waters in Category 3 should not have permits that allow effluent or stormwater to be discharged into them. Discharge permits issued for contributing zones or recharge zones of aquifers that provide water for listed species habitat should not allow degradation of Category 1, 2, or 3 waters such that adverse effects could rise to the level of take of listed animal species, adverse modification of designated critical habitat, or jeopardy of listed plant species pursuant to the ESA. Permits for municipal separate storm sewer systems (MS4s) should eliminate or minimize to the greatest extent possible any impacts on water categories 1, 2, and 3 through discharge during peak wet weather events. New point source discharges or expansions of existing point source discharges involving sites in Category 4 waters that have known populations of listed species or designated critical habitat should be avoided unless a thorough evaluation of all practicable treatment and disposal alternatives by the permit applicant has demonstrated that there is no feasible alternative to discharge into these waters. Limitations on discharges for new point sources or expansions of existing point sources to surface waters upstream of, or tributary to, waters with known populations of aquatic listed species should be implemented such that discharge impacts at the boundary of species habitat will avoid take of listed animal species, adverse modification of designated critical habitat, or jeopardy of listed plant species pursuant to the ESA.

Permits for discharge of treated wastewater should include a description of aquatic listed species and their prey species that are residents or else are likely to pass through a proposed mixing zone including (1) expected locations (if known), (2) stage of development, and (3) time of year when present. The Comal and San Marcos rivers (Category 3) should have permits based on critical low flows that account for the lowest historical flows on record. Category 4 waters with aquatic listed species should have permits based on critical low flows of 1Q10 for acute criteria and 7Q10 for chronic criteria. Discharge permits should not allow ZIDs in any waters where aquatic listed species occur. Freshwater effluents should not be discharged into piping plover habitat on tidal flats along the Texas Gulf Coast.

Pending the outcome of national CWA 304(a) consultations between EPA and the Service, the 3.0 mg/L average daily ammonia limit used for listed species habitat in the implementing document of the TSWQS should be revised on an interim basis according to criteria and procedures in EPA's "Update of ambient water quality criteria for ammonia" (EPA 1999a). Ammonia limits at the edge of mixing zones in the Comal River, San Marcos River, and Category 4 waters should be based on daily maximums rather than daily averages, and permits for these systems should require a frequency of three ammonia samples per week. Permits for effluent discharge into waters with aquatic listed species should also include dechlorination. The Service also recommends that these permits have minimal levels of BOD_5 and the highest level of DO relative to the designated aquatic life use for these waters. An antidegradation evaluation should be required whenever a new or increased loading of any bioaccumulative chemical is proposed for discharge by an existing or new facility or activity, either point source or regulated stormwater.

8.1.1 Biomonitoring

Biomonitoring is used when standard physicochemical, toxicological, or bacteriological parameters are inadequate to estimate the wide range of substances and circumstances that can cause toxicity for aquatic organisms. A biomonitoring program generally uses whole-effluent toxicity (WET) testing to measure the aggregate toxic effect of effluents on receiving waters. WET testing consists of serial dilution tests with test organisms and is conducted with the most appropriate endpoints (e.g., mortality), duration (48 hours for acute tests, 7 days for chronic tests), and species (freshwater or saltwater). WET testing is generally limited to point (e.g., municipal outfalls) or nonpoint (e.g., stormwater runoff) sources in urban areas and is ordinarily not conducted for nonpoint sources of contaminants in non-urban watersheds. In Texas, the minimum frequency of testing for WET permits is once per quarter for the five-year duration of a permit. This testing frequency may not adequately protect aquatic listed species against potential changes in toxicity from effluent discharges. WET testing to protect aquatic listed species may also be limited by the number of methods and species approved for surrogate testing. Currently, EPA has only one approved toxicity method for aquatic plants. The method relies on a single green algal species (*Selenstrum capriconutum*) for chronic freshwater testing.

Only a limited number of studies have actually used listed species in toxicity testing instead of surrogate test organisms. In particular, very few toxicity studies have been conducted with aquifer species (Notenboom et al. 1994). Closely related aquatic species generally respond similarly to toxicity as compared to species with different taxonomic compositions (LeBlanc 1994, Maltby et al. 2005); however, aquatic listed species can be more sensitive to a particular contaminant than standard surrogate test species (Besser et al. 2005, Dwyer et al. 2005a, Dwyer et al. 2005b). Besser et al. (2005) reported that effect concentrations of pentachlorophenol (PCP) were lower for the endangered fountain darter by a factor of three as compared to PCP effect concentrations for rainbow trout and by a factor of six as compared to fathead minnow. Besser et al. (2005) also found that effect concentrations of PCP and copper were lower for the fountain darter than water quality criteria currently established for chronic toxicity. Additional safety factors or specific tests with chemicals of concern may be needed with respect to development of appropriate water quality criteria for aquatic listed species (Sappington et al. 2001, Besser et al. 2005). Dwyer et al. (2005b) recommended that a listed fish species should be directly tested if the species is locally abundant or held in captive stocks. The cold-water rainbow trout provides more comparable sensitivity as a surrogate test species for the fountain darter than the warm-water fathead minnow (Besser et al. 2005, Dwyer et al. 2005b). However, a multi-species approach in toxicity testing generally provides better detection of differences in sensitivity by aquatic species to various chemicals

(Cairns 1986, Teather and Parrott 2006). Dwyer et al. (2005a) concluded that listed fish species were protected 96 percent of the time when both fathead minnow and daphnia (*Ceriodaphnia dubia*) were used as surrogate test species in WET tests.

Recommendations – For aquatic listed species, the Service recommends that biomonitoring and permit limits should be based on the results of testing with a suite of sensitive surrogate test species representative of listed species and their habitat (fish, aquatic arthropod, etc.). Testing with an aquatic monocot plant species should be developed and used as a surrogate test species for Texas wild-rice. The minimum testing frequency in permits for the Comal and San Marcos rivers should be six WET tests (acute and chronic) per year with both daphnia and fathead minnow used as surrogate test species. As a condition of permits for these two river systems, the Service recommends that WET test results be shared with the Service as soon as possible after testing. The Service also recommends that the "Additional Permit Limits" section of the guidance document for implementing TSWQS criteria be modified to require both acute and chronic testing for discharges subject to WET testing. Whole effluent acute toxicity should be determined to be present if the effluent causes more than 25 percent mortality of test organisms when tested at an effluent concentration of 100 percent (P. Jennings, EPA, 2005 – pers. comm.).[36] For discharges that result in an in-stream waste concentration of 10 percent or more, limits for whole effluent chronic toxicity should be based on an in-stream concentration of 100 percent. For discharges resulting in an in-stream waste concentration of less than 10 percent, limits for chronic toxicity in whole effluent testing should be based on the in-stream waste concentration. The Service should be consulted when unrepresentative test species are used, test durations are varied, or other circumstances exist that requires methodology that differs from the TSWQS implementation document.

8.1.2 Concentrated animal feeding operations

Concentrated animal feeding operations (CAFOs) are defined in 40 CFR § 122.23 as a lot or facility where animals (other than aquatic animals) have been, are, or will be stabled or confined and fed or maintained for a total of 45 days or more in any 12-month period. Under 40 CFR § 122.23, a CAFO must be either (1) a large CAFO with large animal numbers (e.g., 700 mature dairy cows; 1,000 cattle other than mature dairy cows or veal calves; 2,500 swine weighing over 55 pounds; and 30,000 laying hens or broilers) or (2) a medium CAFO with medium-sized animal numbers (e.g., 200 to 699 mature dairy cows; 300 to 999 cattle other than mature dairy cows or veal calves; 750 to 3,499 swine weighing over 55 pounds; and 9,000 to 29,999 laying hens or broilers) and meets the condition of either (a) discharging pollutants into waters of the United States through a man-made ditch, flushing system, or other similar man-made device or (b) direct discharge into waters of the United States that originate outside of and pass over, across, or through the facility or otherwise come into direct contact with confined animals. In addition, a state authority (e.g., State Director) or EPA Regional Administrator may designate any animal feedlot operation as a CAFO after determining that the operation is a significant contributor of pollutants to waters of the United States.

The primary pollutant derived from CAFOs is manure (EPA 1999b). Manure wastes in runoff from feedlots vary according to climate, diet, feedlot surface, animal densities, cleaning frequency, and other factors (EPA 1999b). Potential CAFO discharges into surface water or groundwater can occur through

1. Overflow or discharge of retention ponds during periods of intense rainfall and high flooding;

2. Runoff from corrals, manure stockpiles, and silage pits;

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[36] The threshold limit of 25 percent mortality for determining acute toxicity in biomonitoring is used for statistical significance and does not necessarily reflect expected losses of a particular species under natural conditions (P. Jennings, EPA toxicologist, 2005 – pers. comm.).

3. Drainage of manure or applied wastewater from land application areas; and

4. Spills of wastewater due to pipeline breakage or equipment failure.

Potential pollutants from CAFO-generated runoff include nutrients (principally nitrogen and phosphorus), oxygen-demanding organic materials, sediment, ammonia, pathogenic microorganisms (bacteria, viruses, and parasites), heavy metals, hormones, and veterinary pharmaceuticals (Carpenter et al. 1998, EPA 1999b, Huang et al. 2001). Excess nutrients from CAFOs can cause eutrophication and low dissolved oxygen (hypoxia) in aquatic habitats (EPA 1999b). Fish mortality may occur during CAFO discharges due to elevated ammonia concentrations, hypoxia, and high levels of suspended solids. CAFO discharges during heavy rainfall events have caused fish kills in Buffalo Lake National Wildlife Refuge in the Texas Panhandle (Irwin and Dodson 1991, Baker et al. 1998).

Stormwater discharges from CAFOs have the potential to adversely affect aquatic or aquatic-dependent listed species and adversely modify proposed or designated critical habitat. The Arkansas River shiner may be impacted periodically in the Canadian River by the relatively large numbers of CAFOs located in the Texas Panhandle. Aquatic-dependent listed species such as the bald eagle, least interior tern, and Concho water snake could also be affected by CAFO discharges on a local basis due to loss of the fish prey base. Although CAFOs may be located at substantial distances away from areas with listed species or critical habitat, CAFO pollutants can still be carried downstream into these sensitive areas. The increase in numbers of CAFO facilities in Texas represents a potential cumulative threat to a number of listed aquatic and aquatic-dependent species.

All CAFOs covered under the general CAFO permit for Texas (Texas General Permit TXG920000) are prohibited from discharging wastewater into surface waters except for (1) a chronic or catastrophic storm event in excess of a 25-yr, 24-h rainfall event or (2) exceedance of new source performance standards for CAFOS with swine, veal, or poultry as described in 40 CFR § 412.46. If a 25-yr, 24-h rainfall storm event does occur, CAFOs are allowed to discharge stormwater under the assumption that discharged wastes will be diluted to relatively nontoxic concentrations in receiving waters. CAFOs covered under the general permit are required to develop and maintain a pollution prevention plan that identifies potential sources of pollutants in runoff from the facility. In addition, any large CAFO that disposes of wastes by land application is required to develop and implement a nutrient management plan by July 2007. Operators of CAFOs that potentially discharge into surface water are required to collect at least one grab sample of water within 30 minutes from the initial discharge. The sample must be analyzed for (1) total and fecal coliform, (2) 5-d biochemical oxygen demand (BOD_5), (3) total dissolved solids (TDS), (4) total suspended solids (TSS), (5) nitrate (N), (6) ammonia nitrogen, (7) total phosphorus, and (8) any pesticides that may be present in the discharged wastewater.

Recommendations – To help protect aquatic or aquatic-dependent listed species from adverse effects, water bodies or wetlands with these species or critical habitat should not be impacted by CAFO operations. CAFOs of any type should not be permitted for watersheds or drainages with water categories 1, 2, or 3 unless the CAFO is at a sufficient distance that effluent from any discharge cannot be carried into listed species habitat through runoff or groundwater discharge. CAFOs that can adversely affect Category 4 waters with listed species should be designed, constructed, operated, and maintained to contain all manure and process wastewater including runoff from rainstorm events. CAFOs for swine, poultry, or veal that are contained in these watersheds should be capable of achieving a level of zero discharge during a 100-yr, 24-hr rainfall event. All CAFO lagoons for larger feedlot animals (beef, dairy, sheep, or horses) should be designed for either (1) a 50-yr, 24-h event or (2) a 25-yr, 24-h event when sufficient BMPs (filter strips, berms, etc.) are constructed to prevent discharge impacts to the greatest extent possible. CAFO lagoons in watersheds with multiple CAFOs that can affect Category 4 waters simultaneously during periods of extended, heavy precipitation should have both BMPs and a design for a 50-yr, 24-h event. CAFO lagoons should not be located within the 100-yr flood plain of a Category 4 water body. Pre-project information on water quality and post-project monitoring should be required of any permitted CAFOs to determine project effects on surface water and groundwater involving Category 4 waters. Long-term monitoring of water quality and aquatic habitats should be conducted in watersheds that have Category 4 waters and multiple CAFOs to determine impacts of CAFO permitting to habitat of listed species. CAFO lagoons or land applications should not be permitted in watersheds with Category 4 waters that have a high likelihood of groundwater contamination such as areas with shallow groundwater, fractured or cavernous bedrock, or highly permeable soils that would allow contaminants to enter groundwater. Land applications of CAFO wastes should not cause any loading of nutrients or other pollutants in Category 1, 2, and 3 waters; and loading of nutrients and other pollutants into Category 4 waters from land application of CAFO wastes should be eliminated or minimized to the greatest extent possible.

8.1.3 TPDES permits and net ecological benefits for federally listed species

In some instances, a return flow of discharge effluent may be used to replace depleted water flow in areas of Texas with limited water resources. Unless toxic contaminants are present, discharge of effluent in such areas could potentially benefit listed species by creating or supporting riparian or aquatic habitat that otherwise would not exist. Water quality criteria for nontoxic materials in the discharged effluent may therefore be exceeded on the basis that net ecological benefits to these species outweigh any harm ordinarily associated with the effluent itself. However, return flows of discharge effluent in waters with listed species generally should not be permitted unless a thorough evaluation of all practicable treatment and disposal alternatives by the permit applicant has demonstrated that there is no feasible alternative to discharge into these waters.

<u>Recommendations</u> – A water quality criterion for nontoxic parameters (salinity, pH, etc.) may be exceeded in discharge areas with listed species if it is demonstrated that

1. The discharge of effluent creates or supports an ecologically valuable aquatic habitat, wetland, or riparian ecosystem for a listed species in an area where such resources are nonexistent or limited;

2. The ecological benefits associated with discharge of effluent under an exceeded water quality criterion would be greater than the environmental costs that would be incurred by eliminating the discharged effluent;

3. Increased levels of the exceeded parameter in the effluent will not produce synergisms, chemical activations, or other effects that can cause higher toxicities for listed species to occur in the habitat;

4. The discharge of effluent does not produce or contribute to the concentration of a pollutant in tissues of aquatic organisms or wildlife or have any other adverse effect that is likely to be harmful to listed species through acute or chronic toxicity or through bioaccumulation;

5. The discharge of effluent will not allow invasive species to enter aquatic habitat of listed species;

6. The discharged effluent will be removed through filtration, dilution with a perennial water body, or other processes of elimination within the ecologically valuable aquatic habitat, wetland, or riparian ecosystem; and

7. All practical control programs for point source discharge are implemented including pretreatment, waste minimization, and source reduction programs.

8. The Service has been consulted for the project or activity proposing to use discharged effluent as a replacement for depleted water flow in habitat of the listed species.

8.2 Site-Specific Uses and Criteria for Waters with Federally Listed Species

For certain water bodies, local water conditions may warrant different criteria or designated uses than those stipulated in the TSWQS. A site-specific standard for these local conditions may be adopted as an amendment to the TSWQS with approval from EPA. The adopted site-specific standard cannot impair an existing use, attainable use, or designated use. A temporary variance may be given to an existing facility before or during a permit application process to allow adequate time for the operator to gather information in support of a site-specific standard. Various types of modeling are used to justify a variance or site-specific standard including modeling such as Water Effects Ratios (WERs) and Biotic Ligand Modeling. Variances or site-specific amendments to the TSWQS may be based on

1. Background concentrations of specific toxics of concern in receiving waters, sediment, or indigenous biota;

2. Persistence and degradation rate of specific toxic materials;

3. Synergistic, additive, or antagonistic interactions of toxic substances with other toxic or nontoxic materials;

4. Measurements of total effluent toxicity;

5. Indigenous aquatic organisms, which may have different responses to particular toxic materials;

6. Technological or economic limits of treatment for specific toxic materials;

7. Bioavailability of specific toxic substances of concern, as determined by water-effect ratio tests or other analyses approved by the agency; and

8. New information concerning the toxicity of a particular substance.

TPDES permits with an approved variance may be issued for up to three years (with a possibility for extension) and have provisions for the study of stream characteristics, aquatic life uses, or other site-specific information about the receiving water. For unclassified waters, a use attainability analysis (UAA) is conducted to determine whether the attainable aquatic life use for a particular unclassified water body is lower than the presumed aquatic life use.[37] Once the site-specific standard is adopted, effluent limits in existing TPDES permits can be amended to reflect the new standard. In certain cases, a temporary standard for a specific water body may be adopted when a criterion cannot be attained for various reasons such as an inability to attain a particular use due to natural, ephemeral, intermittent, or low-flow conditions or water levels. A temporary standard is required to expire at the completion of the next triennial revision of the TSWQS.

Development of variances, site-specific standards, and temporary standards for the TSWQS has the potential to affect aquatic and aquatic-dependent listed species or critical habitat in Texas. In some cases, more stringent criteria and uses can be developed to protect listed or proposed species when such site-

[37] UAAs are also conducted on classified streams to determine whether the attainable aquatic life use is lower than the designated use.

specific modifications are necessary to ensure that water quality is not likely to jeopardize the continued existence of such species or result in the destruction or adverse modification of such species' critical habitat. Pursuant to CWA section 510, aquatic life criteria or values may be modified by states or tribes on a site-specific basis to provide an additional level of protection.

Recommendations – To help protect aquatic or aquatic-dependent listed species from adverse effects, any site-specific modifications that result in less stringent criteria should have a sound scientific rationale and should not likely jeopardize the continued existence of proposed or listed species or result in the destruction or adverse modification of such species' critical habitat. Aquatic life criteria or values may be modified on a site-specific basis to provide an additional level of protection. Water categories 1, 2, and 3 should not have site-specific modifications due to anthropogenic causes or be impacted by site-specific modifications up-gradient of listed species habitat. In making determinations regarding the lowering of water quality in Category 4 waters, the anticipated impact of the proposed lowering of water quality on listed species and the biological integrity of their aquatic habitat should be considered. Presence of individual species should be determined according to seasonality, migration, and intermittency. Multiple samples taken over a number of time periods may be necessary to determine whether taxa present in a water body proposed for site-specific modification are seasonal or migratory. The habitat range of listed species should be considered if the species has become absent due to degraded conditions but potentially may return once site conditions improve. Appropriate reference sites should be used for conducting use attainability analyses or biotic indexes, and resident species in a site proposed for the site-specific modifications should be evaluated as to whether these species reflect normal species composition or species tolerant of on-site toxic materials.

The Service recommends that development of site-specific criteria should be based on an ecological risk assessment that follows EPA's "Guidelines for Ecological Risk Assessment" (EPA doc. no. EPA/630/R-95/002F). The risk assessment should include:

1. Identification and evaluation of potential stressing elements (stressors) from data of monitoring networks, NPDES/TPDES permit databases, scientific literature, and other sources pertinent to waters and water body sediments;

2. Following the three-tiered process of problem formulation, analysis, and risk characterization as described in "Guidelines for Ecological Risk Assessment" including the establishment of stressors, assessment endpoints, and conceptual models; and

3. Evaluation of criteria and designated uses in the TSWQS with respect to exposure of listed species and their habitat to individual stressors.

The most restrictive criteria from different segments within a watershed should be used as default criteria if data are unavailable for segments known to have listed species. Bioaccumulation factors (BAFs) or bioaccumulation concentration factors (BCFs) developed under site-specific modification processes should not cause chronic toxicity for listed species and should consider both the mobility of listed species and their prey or other food sources.

SECTION 9

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Appendix A

Maximum contaminant levels (MCLs) required by the Safe Drinking Water Act for public drinking water systems using Category 1 and 2 waters.

Maximum contaminant levels for organic contaminants applying to community and non-transient, non-community water systems

Contaminant	MCL (mg/L)
Vinyl chloride	0.002
Benzene	0.005
Carbon tetrachloride	0.005
1, 2-Dichloroethane	0.005
Trichloroethylene	0.005
para-Dichlorobenzene	0.075
1, 2-Dichloroethylene	0.007
1, 1, 1-Trichloroethane	0.2
cis-1, 2-Dichloroethylene	0.07
1, 2-Dichloropropane	0.005
Ethylbenzene	0.7
Monochlorobenzene	0.1
o-Dichlorobenzene	0.6
Styrene	0.1
Tetrachloroethylene	0.005
Toulene	1
trans-1, 2-Dichloroethylene	0.1
Xylenes (total)	10
Dichloromethane	0.005
1, 2, 4-Trichlorobenzene	0.07
1, 1, 2-Trichloroethane	0.005

Maximum contaminant levels for synthetic organic contaminants

Contaminant	MCL (mg/L)
Alachlor	0.002
Aldicarb	0.003
Aldicarb sulfoxide	0.004
Aldicarb sulfone	0.003
Atrazine	0.003
Carbofuran	0.04
Chlordane	0.002
Dibromochloropropane	0.0002
2, 4-D	0.07
Ethylene dibromide	0.00005
Heptachlor	0.0004

Heptachlor epoxide	0.0002
Lindane	0.0002
Methoxychlor	0.04
Polychlorinated biphenyls	0.0005
Pentachlorophenol	0.001
Toxaphene	0.003
2, 4,5-TP	0.05
Benzo[a]pyrene	0.0002
Dalapon	0.2
Di (2-ethylhexyl)adipate	0.4
Di (2-thylhexyl)phthalate	0.006
Dinoseb	0.007
Diquat	0.02
Endothall	0.1
Endrin	0.002
Glyphosate	0.7
Hexachlorobenzene	0.001
Hexachlorocyclopentadiene	0.05
Oxamyl (Vydate)	0.2
Picloram	0.5
Simazine	0.004
2, 3, 7, 8-TCDD (Dioxin)	3 x 10-8

Maximum contaminant levels for inorganic contaminants applying to community and non-transient, non-community water systems

Contaminant	MCL (mg/L)
Fluoride	4.0
Asbestos	7 million fibers/liter
Barium	2
Cadmium	0.005
Chromium	0.1
Mercury	0.002
Nitrate	10 (as Nitrogen)
Nitrite	1 (as Nitrogen)
Total Nitrate and Nitrite	10 (as Nitrogen)
Selenium	0.05
Antimony	0.006
Beryllium	0.004
Cyanide (as free Cyanide)	0.2
Thallium	0.002
Arsenic	0.01

Appendix B

Ecological benchmarks for sediment in Table 3-3 of TCEQ's "Guidance for Conducting Ecological Risk Assessments at Remediation Sites in Texas" (RG-263, December 2001, revised).

CAS #	Constituent	Freshwater	Marine
Inorganics (mg/kg dry wt.)			
7440-36-0	Antimony	2 [a]	
7440-38-2	Arsenic	5.9	8.2
7440-43-9	Cadmium	0.596	1.2
7440-47-3	Chromium	37.3	81
7440-50-8	Copper	35.7	34
7439-89-6	Iron	20,000 [b]	
7439-92-1	Lead	35	46.7
7439-96-5	Manganese	460[b]	
7439-97-6	Mercury	0.174	0.15
7440-02-0	Nickel	18	20.9
7440-22-4	Silver	1[a]	1
7440-66-6	Zinc	123	150
Polycyclic Aromatic Hydrocarbons (mg/kg dry wt.)			
83-32-9	Acenaphthene		0.016[j]
208-96-8	Acenaphthylene		0.044[j]
120-12-7	Anthracene	0.0572 [e, j]	0.0853 [j]
56-55-3	Benz(a)anthracene	0.0317 [j]	0.261 [j]
50-32-8	Benzo(a)pyrene	0.0319[j]	0.43 [j]
218-01-9	Chrysene	0.0571 [j]	0.384 [j]
53-70-3	Dibenz(a,h)anthracene	0.033 [e, j]	0.0634 [j]
206-44-0	Fluoranthene	0.111 [j]	0.6 [j]
86-73-7	Fluorene	0.0774 [e, j]	0.019 [j]
91-57-6	2- Methyl naphthalene		0.070 [j]
91-20-3	Naphthalene	0.176 [e, j]	0.160 [j]
85-01-8	Phenanthrene	0.0419 [j]	0.24 [j]
129-00-0	Pyrene	0.053[j]	0.665 [j]
	Low Molecular Weight PAHs		0.552 [,f, g, j]
	High Molecular Weight PAHs		1.7 [f, h, j]
	Total PAHs	4 [b, f, i, j]	4.022 [f, i, j]
Pesticide/PCB (mg/kg dry wt.)			
309-00-2	Aldrin	0.002 [b]	
27323-18-8	Aroclor 1254	0.060 [b]	
12674-11-2	Aroclor 1016	0.007 [b]	
11096-82-5	Aroclor 1260	0.005 [b]	
12672-29-6	Aroclor 1248	0.030 [b]	
319-84-6	alpha-BHC	0.006 [b]	
319-85-7	beta-BHC	0.005 [b]	
58-89-9	gamma-BHC (Lindane)	0.00094	0.00032 [d]
608-73-1	BHC	0.003 [b]	
57-74-9	Chlordane (Total)	0.0045	0.00226 [d]
60-57-1	Dieldrin	0.00285	0.000715 [d]

72-20-8	Endrin	0.00267	
118-74-1	HCB (Hexachlorobenzene)	0.020 [b]	
1024-57-3	Heptachlor epoxide	0.0006	
2385-85-5	Mirex	0.007 [b]	
72-55-9	Sum DDE*	0.00142 [c, f]	0.00207 [d, f]
72-54-8	Sum DDD*	0.00354 [c, f]	0.00122 [d, f]
50-29-3	Sum DDT*	0.00119 [c, f]	0.00119 [d, f]
	Total DDT	0.007 [f]	0.00158 [f]
1336-36-3	Total PCBs	0.0341 [f]	0.0227 [f]
Phthalates (mg/kg dry wt.)			
117-81-7	Bis(2-ethyl-hexyl)phthalate		0.182 [d]

*Sum of the p-, p'- and o-, p'- isomers.

Freshwater - Unless otherwise noted, benchmarks are Threshold Effects Level (TEL) from: Smith, S.L., D.D. MacDonald, K.A. Keenleyside, C.G. Ingersoll, and L.J. Field. 1996a. A Preliminary Evaluation of Sediment Quality Assessment Values for Freshwater Ecosystems. J. Great Lakes Res. 22(3):624-638.

Marine - Unless otherwise noted, benchmarks are Effects Range Low (ERL) from: Long, E.R., D.D. MacDonald, S.L. Smith, and F.D. Calder. 1995. Incidence of Adverse Biological Effects Within Ranges of Chemical Concentrations in Marine and Estuarine Sediments. Environ. Manage. 19(1):81-97.

a Effects Range Low (ERL) from: Long, E.R. and L.G. Morgan. 1990. The Potential for Biological Effects of Sediment-sorbed Contaminants Tested in the National Status and Trends Program. NOAA Technical Memorandum NOS OMA 52, March 1990.

b Lowest Effects Level (LEL) from: Persaud, D., R. Jaagumagi and A. Hayton. 1993. Guidelines for the Protection and Management of Aquatic Sediment Quality in Ontario. Water Resources Branch. Ontario Ministry of the Environment and Energy. August.

c Interim Sediment Quality Guidelines (ISQG) from: Environment Canada. 1997. Canadian Sediment Quality Guidelines for DDTs. Environment Canada, Guidelines and Standards Division. January, 1998 Draft.

d Threshold Effects Level (TEL) from: Smith, S.L., D.D. MacDonald, K.A. Keenleyside, and C.L. Gaudet. 1996b. The Development and Implementation of Canadian Sediment Quality Guidelines. In: Development and Progress in Sediment Quality Assessment: Rationale, Challenges, Techniques & Strategies. Ecovision World Monograph Series. Munawar & Dave (Eds.). Academic Publishing, Amsterdam, The Netherlands.

e Threshold Effect Concentration (TEC) from: MacDonald, D.D., C.G. Ingersoll, and T.A. Berger. 2000. Development and Evaluation of Consensus-Based Sediment Quality Guidelines for Freshwater Ecosystems. Arch. Environ. Contam. Toxicol. 39:20-31.

f When benchmarks represent the sum of individual compounds, isomers, or groups of congeners, and the chemical analysis indicates an undetected value, the proxy value specified at §350.51 (n) shall be used for calculating the sum of the respective compounds, isomers, or congeners. This assumes that the particular COC has not been eliminated in accordance with the criteria at §350.71 (k).

g The low molecular weight PAH benchmark is to be compared to the sum of the concentrations of the following compounds: naphthalene, acenaphthylene, acenaphthene, fluorene, phenanthrene, anthracene, and 2-methyl napthalene. The PAH benchmark is not the sum of the corresponding benchmarks listed for the individual compounds.

h The high molecular weight PAH benchmark is to be compared to the sum of the concentrations of the following compounds: fluoranthene, pyrene, benz(a)anthracene, chrysene, benzo(a)pyrene, and dibenzo[a,h]anthracene. The PAH benchmark is not the sum of the corresponding benchmarks listed for the individual compounds.

I Total PAH refers to the sum of the concentrations of each of low and high molecular weight PAHs listed above and any other PAH compounds that are not eliminated in accordance with §350.71 (k).

j PAH compounds must be compared with individual benchmark values as well as those for low molecular weight PAHs, high molecular weight PAHs, and total PAHs.

Appendix C

ESA consultations on water quality for federally listed species in Texas include biological opinions for (1) the 1997 triennial review of the state's water quality standards and (2) the 1998 authorization of Texas Pollutant Discharge Elimination System (TPDES).

A. 1997 TRIENNIAL REVIEW OF THE TSWQS

A biological opinion on the 1997 triennial review of the TSWQS was issued to EPA by the Service field office in Corpus Christi, TX on February 25, 1998. The biological opinion had the following reasonable and prudent measures with terms and conditions to minimize take associated with revised standards:

Reasonable and Prudent Measures –

1. Determine and promulgate water quality and minimum flow standards consistent with the conservation of highly sensitive threatened and endangered aquatic species.

2. Apply the standards to the Texas waters in which the threatened and endangered species occur.

Terms and Conditions –

1. By 2000, develop a database of permitted discharges, in conjunction with U.S. Fish and Wildlife Service and the State that lists discharges to water bodies supporting aquatic or aquatic-dependent threatened and endangered species.

2. Strongly recommend that the State adopt EPA numerical criteria for ammonia for discharges into receiving water supporting aquatic and aquatic-dependent threatened and endangered species.

3. Work with the State in adopting a narrative criterion for chlorine that is protective of aquatic and aquatic-dependent threatened and endangered species.

4. Recommend that the State evaluate segments subject to spring flows that are affected by groundwater pumping, and determine a critical low flow protective of endangered and threatened species.

5. Recommend that the State evaluate the diazinon standard in light of EPA's latest criteria document during the next triennial review.

B. TEXAS POLLUTANT DISCHARGE ELIMINATION SYSTEM (TPDES)

A biological opinion was issued by the Service field office in Austin, TX in September 14, 1998 on the EPA's authorization of the TPDES program by the State of Texas. Reasonable and prudent measures stipulated by the September 14, 1998 biological opinion were

1. Develop and implement procedures to facilitate inter-agency cooperation in the review and oversight of the TPDES permitting program,

2. Develop and implement coordination procedures between EPA and the Service on EPA's review of the development and revision of Texas Water Quality Standards, and

3. Develop and implement a monitoring effort to ensure that the issuance of a TPDES permit is not significantly affecting listed species and designated critical habitat or resulting in take beyond that anticipated by the Biological Opinion.

Terms and Conditions

In order to be exempt from the prohibitions of section 9 of the Act, EPA must comply with the following terms and conditions, which implement the reasonable and prudent measures described above and outline required reporting/monitoring requirements. These terms and conditions are non-discretionary.

Terms and Conditions to Implement Reasonable and Prudent Measure 1

This term and condition is effective immediately. In an effort to minimize the potential for the take of listed species and adverse impacts to designated critical habitat in the State of Texas, the Service is committed to working cooperatively with EPA to achieve our mutually shared objectives of protecting the quality of waters of the Texas and the species that depend on those waters. To facilitate collaboration for planning and prioritizing future CWA/Exactions and resolving any potential conflicts or disagreements, and to develop a structured, time-sensitive process at the lowest possible level, the agencies will follow the coordination and elevation procedures described below.

1. Local/Regional Coordination

Staff from the Dallas Regional Office of EPA and the Texas Ecological Services Field Offices of the Service will, as appropriate:

a. Meet at least annually;

b. Identify upcoming workload requirements and provide input on upcoming activities such as annual work plans, triennial water quality standards reviews, recovery plan preparation, proposed listings, or proposed habitat conservation planning efforts;

c. Identify high priority areas of concern and opportunities for cooperation. These areas may be geographic (ecosystems, basins, stream segments, etc.), they may be life form (species, trophic level, etc.), they may be pollutant (by chemical or by industrial or source category, etc.), or they may fall into some other category such as cooperation in basin planning or in habitat conservation planning;

d. Assist one another in determining which categories of TPDES permits are of priority for review by EPA and the Service for endangered species concerns;

e. Identify training needs; and

f. Evaluate past agency actions related to NPDES permits, including developing mechanisms on ways to reduce impacts to listed species.

2. Conflict/Dispute Resolution

General: The following procedures shall be utilized to elevate any conflict or disagreement between the agencies. Decisions by all levels, including decisions to elevate, will be made by consensus to the greatest extent practicable. The Agencies recognize, however, that consensus may not always be possible. Each agency will continue to exercise its statutory or regulatory authority over the issues in question and make those final decisions appropriate to it. Either EPA or the Service can initiate the elevation process. While elevation should be taken only as a last resort, it must be made so that all applicable deadlines may be met, taking into account subsequent levels of review. If any level decides to elevate an issue, the personnel from relevant agencies will prepare a summary of the issue to be elevated, including an explanation of each Agency's position on the issue. Where the Agencies agree, the summary will be prepared jointly. If the agencies are aware of a dispute, they will defer taking final action, where consistent with applicable legal deadlines, to allow the issue to be resolved through the elevation process. The time periods specified below are intended to facilitate expeditious resolution of the issues. The time periods begin to run on the date that the elevating agency or agencies notify the next level of the elevation request. All prescribed time frames in the elevation process can be waived by the mutual consent of the participants at any level when the participants believe that progress is being made and that resolution at that level is still possible.

a. Level 1: The Level 1 review team consists of staff personnel from the Dallas EPA Regional Office and the Texas Ecological Services Field Offices of the Service. The overall goal is to design actions to minimize adverse impacts to listed species after the NPDES program is assumed by the State of Texas. Any contentious issues will be discussed with an attempt to resolve them without elevation. If disputes cannot be resolved among the Level 1 team members, the issue will be raised with the Level 2 review team as soon as possible.

b. Level 2: The Level 2 review team consists of field unit line officers or staff supervisors, for EPA, branch chiefs; and for the Field Supervisor of the appropriate Texas Ecological Services Field Office of the Service. The Level 2 team will make their best efforts to resolve any issues elevated to them. Where resolution is not possible at this level, the Level 2 team will elevate the issue to the Level 3 team no later than 14 days after notification by the Level 1 team, or sooner as agreed upon or mandatory deadlines require.

c. Level 3: The Level 3 review team consists of the Regional Administrator of EPA and the Regional Director of the Service's Southwest Regional Office. Their function is to resolve any elevated disputes within 21 days of notification of elevation by Level 2 teams, or sooner as necessary to meet mandatory deadlines, and serve as key advisors on policy and process. If issues are not resolved by the Level 3 team, the issue will be elevated for Headquarters Review.

d. Headquarters Review: This review consists of the Director of the Director of the Service, and the Deputy Assistant Administrator of Water at EPA or their representatives who shall attempt to resolve disputes elevated by the regional executives. Agency administrators shall attempt to issue a decision resolving the issue within 21 days after elevation. Decisions will be binding upon the agencies' field staffs. Agency administrators or their designees shall make every attempt to resolve the dispute before elevation, where necessary, to the Assistant Secretaries of the Departments of Interior/Commerce and the Assistant Administrator of EPA. The responsible Assistant Secretary(s) and Assistant Administrator shall resolve any issues within 21 days of elevation. At this resolution level, the decision must rest with the agency exercising the statutory or regulatory authority in question.

Terms and Conditions to Implement Reasonable and Prudent Measure 2

This term and condition is effective immediately.

1. Development of New or Revised State or Tribal Water Quality Standards-EPA will communicate and, where required under section 7 of the ESA, consult with the Services on new or revised Texas water quality standards and implementing procedures that are subject to EPA review and approval under section 303(c) of the CWA. If the State of Texas requests, or upon mutual agreement, EPA may, by notifying the

Service in writing, designate the State to serve as a non-Federal representative to conduct informal consultation in accordance with 50 CFR § 402.08.

a. Scoping of Issues to be Considered During the Triennial Review Process

Section 303(c) of the CWA requires states to adopt and revise standards at least on a triennial basis. The Service and EPA recognize that to accomplish timely implementation of standards that may affect federally listed species and designated critical habitat, early involvement and technical assistance by the Services is needed. EPA will contact the Service to arrange a meeting to be held during the period when EPA and the State of Texas can discuss the extent of upcoming triennial reviews.

b. Development of State or Tribal Standards

EPA will seek the technical assistance and comments of the Service during the State of Texas' development of water quality standards and related policies. The Service will provide the State of Texas and EPA with information on federally listed species, proposed species and proposed critical habitat, and designated critical habitat in the State. EPA will provide assistance to the Service in obtaining descriptions of pollutants and causes of water quality problems within a watershed or ecosystem. The Service will work cooperatively with the State of Texas to identify any concerns the Service may have and how to address those concerns. EPA will request the Service to review and comment on draft standards, and to participate in meetings with the State as appropriate. EPA will indicate which of these requests are of high priority, and the Service will make every effort to be responsive to these requests.

Where appropriate, EPA and the Service will encourage the State to adopt special protective designations where listed or proposed threatened or endangered species are present or critical habitat is designated or proposed.

EPA will initiate discussions with the Service if there is a concern that a draft State standard or relevant policy may impact federally listed species or critical habitat.

c. Adoption and Submittal of State Standards

States adopt new and revised standards and implementing policies from time to time as well as at the conclusion of the triennial review period.

After the final action adopting the standards, the State sends its adopted and effective standards to EPA. Once received, EPA is required by the CWA to approve the standards within 60 days or disapprove them within 90 days. Section 7 consultation is required if EPA determines that any of the standards may affect listed species or designated critical habitat. The time periods established by the CWA require that EPA and the Service work effectively together to complete any needed consultation on a State's standards quickly. In order to provide enough time for consultation with the Service where the approval may affect endangered or threatened species, EPA will work with the State with the goal of providing to the Service a final draft of the water quality standards submission 90 days prior to the State's expected submission of the standards to EPA. When needed, EPA will prepare a Biological Evaluation based on the final draft and, where appropriate, request formal consultation. The Service will make every effort to complete consultation and delivery of a final Biological Opinion within 90 days, or on such other schedule as agreed upon with the EPA Regional Office.

d. EPA Develops Biological Evaluation

When needed, EPA will develop a biological evaluation to analyze the potential effect of any new or revised State adopted standards that may affect federally listed species or critical habitat.

e. EPA Determination of "No Effect" or "May Affect"

EPA will evaluate proposed new or revised State standards and use any biological evaluation or other information to determine if the new or revised standards “may affect” a listed species or critical habitat. For those standards where EPA determines that there is "no effect", EPA may record the determination for its files and no consultation is required. Although not required by section 7 of the ESA, EPA will share any biological evaluation, "no effect" determination, and supporting documentation used to make a “no effect” determination with the Services upon request.

If EPA decides that the new or revised water quality standards "may affect" a listed species, then EPA will enter into informal consultation (unless EPA decides to proceed directly to formal consultation) to determine if the standards are likely to adversely affect or not likely to adversely affect federally listed species or critical habitat. If EPA determines that the species or critical habitat is not likely to be adversely affected, EPA will request the Service to concur or not concur with its finding (see 6 below).

Where EPA finds that a species or critical habitat is likely to be adversely affected, EPA will consider, and the Service may suggest, modifications to the standards(s) or other appropriate actions which would avoid the likelihood of adverse effects to listed species or critical habitat. If the likelihood of adverse effects cannot be avoided during informal consultation, then EPA will initiate formal consultation with the Service or EPA may choose to disapprove the standard. In addition, if EPA finds that a proposed species is likely to be jeopardized or proposed critical habitat adversely modified by EPA approval of a new or revised State standard, EPA will conference with the Service under 50 CFR § 402.10.

f. Service Review of "Not Likely to Adversely Affect” Determination

Within 30 days after EPA submits a “not likely to adversely affect” determination, the Service will provide EPA with a written response that they concur or do not concur with EPA's findings. The Service will provide EPA with one of the three following types of written responses: 1) concurrence with EPA's determination (this would conclude consultation), 2) non-concurrence with EPA's determination and, if the Service cannot identify the specific ways to avoid adverse effects, a request that EPA enter into formal section 7 consultation (see 7 below), or 3) a request that EPA provide further information on their determination. If it is not practicable for EPA to provide further information, the Service will make a decision based on the best available scientific and commercial information.

g. Formal Consultation

Formal consultation on new or revised standards adopted by the State of Texas will begin on the date the Service and EPA jointly agree that the information provided is sufficient to initiate consultation under 50 CFR § 402.14(c). The consultation will be based on the information supplied by EPA in any biological evaluation and other relevant information that is available or which can practicably be obtained during the consultation period (see 50 CFR § 402.14(d) and (f)).

If the Service anticipates that incidental take will occur, the Service's biological opinion will specify reasonable and prudent measures to minimize such take, and terms and conditions to implement those measures. Reasonable and prudent measures and terms and conditions should be developed in close coordination with the EPA and the State of Texas, to ensure that the measures are reasonable, that they cause only minor changes to the proposed action, and that they are within the legal authority and jurisdiction of the Agency and the State to carry out.

As a general matter, EPA disapproval of a State water quality standard is not a minor undertaking because it triggers a legal duty on the part of EPA to initiate promptly Federal rulemaking unless the State revises the standard within 90 days (see CWA 303(c)(3) and (4)). Where the Service and EPA agree, however, disapproval of a State water quality standard may be included as a condition of incidental take authorization.

The Service will issue a biological opinion that concludes whether any federally listed species is likely to be jeopardized or critical habitat adversely modified or destroyed by the State's new or revised water quality standards. If the Service makes a jeopardy or adverse modification finding, it will identify any available reasonable and prudent alternatives.

h. EPA Action on State Standards

Upon receipt of a biological opinion, EPA will inform the Service of its intended action.

2. Existing State Water Quality Standards

If the Service presents information to EPA, or EPA otherwise has information supporting a determination that existing Texas water quality standards are not adequate to avoid jeopardizing endangered or threatened federally listed species or adversely modifying critical habitat or for protecting and propagating fish, shellfish and wildlife, EPA will work with the State of Texas in the context of its triennial review process to obtain revisions in the standards. Such revisions could include, where appropriate, adoption of site-specific water quality standards tailored to the geographic range of the species of concern. If the State of Texas does not make such revisions, the EPA regional office will recommend to the EPA Administrator that a finding be made under section 303(c)(4)(B) of the CWA that the revisions are necessary.

EPA will engage in section 7 consultation to ensure that any revisions to the existing standards aren't likely to jeopardize the continued existence of endangered or threatened species or result in the destruction or adverse modification of designated critical habitat and to minimize any anticipated incidental take. If EPA and the Service disagree regarding the need for revisions instate standards, the issue may be elevated. Consultation will be consistent with the provisions of 50 CFR § 402.

3. Consultation on EPA Promulgation of State Water Quality Standards

EPA promulgation of State water quality standards is a Federal rule making process and EPA will comply with the requirements of section 7 of the ESA with any promulgation.

Terms and Conditions to Implement Reasonable and Prudent Measure 3

EPA shall conduct water quality monitoring using its existing programs, monitoring by the State, reports by permittees, or other appropriate information to assess the impacts of the assumption of NPDES permitting authority by the State of Texas on the incidental take on listed aquatic organisms. While no lethal take is anticipated and therefore, not exempted, the Service has acknowledged that take in the form of harm and harassment is anticipated from the proposed action and that it may significantly affect the breeding, feeding, and sheltering of listed species. Priorities for developing monitoring initiatives will generally include those species that are most at risk, those species where TPDES activity is the greatest and the water quality life history requirements are least known, and those stream segments harboring listed species where multiple TPDES discharges potentially could result in having synergistic effects. Developing water quality baseline information where it presently does not exist is a high priority for monitoring. Where appropriate, monitoring efforts may be multi-year efforts. Should disagreements between the Service and EPA occur in defining the scope or extent of the monitoring program required by this Term and Condition, such issues should be resolved using the conflict resolution procedures identified in Terms and Conditions for Reasonable and Prudent Measure 1, section 2. (Conflict/Dispute Resolution). In an effort to more accurately assess the extent of this take and develop strategies for minimizing the effects of TPDES discharges on listed species, the following must occur:

1. Annually (beginning one year from the date of signature of this Biological Opinion), staff from the Dallas Regional Office of EPA and the Service's Texas Ecological Services Field Offices will meet to identify those water bodies that will be monitored for the effects of NPDES permit discharges on listed species and the type of monitoring programs to be established and discuss the results of the previous year's monitoring efforts;

2. EPA will submit to the Service for approval the monitoring programs to be established within two months of the annual meeting; and

3. Upon approval EPA will initiate the monitoring studies and submit agreed upon reports to the Service in a timely manner.

The reasonable and prudent measures, with their implementing terms and conditions, are designed to minimize the impact of incidental take that might otherwise result from the proposed action. If, during the course of the action, this level of incidental take is exceeded, such incidental take represents new information requiring re-initiation of consultation and review of the reasonable and prudent measures provided. EPA must immediately provide an explanation of the causes of the taking and review with the Service the need for possible modification of the reasonable and prudent measures.